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National
Semiconductor

# Semiconductor Master Selection Guide

1988

- 1987 Selection Guide for National Products
- 1987 Selection Guide for Fairchild Products
- New Product Updates for 1988

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- ■ 1987 Selection Guide for National Products
- ■ 1987 Selection Guide for Fairchild Products
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**National Semiconductor**

# “When I’m looking for solutions, I look to National.”

### INTERFACE

***“I’ve got a great CPU design and National’s high quality interfaces will help ensure its maximum performance.”***

COMMUNICATION SUPPORT
- controllers
- local area network
- receivers
- transmitters
- communication processors

DISK SUPPORT
- floppy
- hard

DISPLAY CONTROLLERS/DRIVERS
- CRT controllers
- display drivers

GRAPHICS
- video shift registers
- video clock generators
- video RAM controller
- BIT BLT processing unit
- raster graphics processor
- video DACs

LEVEL TRANSLATORS/ BUFFERS

MEMORY SUPPORT
- DRAM controllers
- drivers
- error checking and correction circuits
- registers

PERIPERAL/POWER DRIVERS

TRANSMISSION LINE DRIVERS/RECEIVERS
- line drivers
- line receivers

FREQUENCY SYNTHESIS
- phase locked loop frequency synthesizers

BUS TRANSCEIVERS

### MIL-AERO

***“Our country has critical needs, and National combines the resources and responsiveness to meet them.”***

ASICs
- gate array

LOGIC
- FAST
- FACT
- CMOS and Bipolar
- TTL
- std Schottky
- 54 HC

LINEAR

DISCRETES

HYBRIDS

MOS MEMORY
- MOS & CMOS EPROM/ SRAM

BIPOLAR MEMORY
- PROM and Programmable Logic (PAL®) devices

MICROPROCESSOR
- 8-, 16- and 32-bit

VHSIC
- Custom
- 64 K-bit
- CMOS RAM

### PACKAGING

***“Reliable packaging is critical for my applications. So I call National.”***

- Small Outline (SO) with 3-28 lead counts on .050 inch centers in “gullwing” configuration on two package sides
- Plastic Leaded Chip Carrier (PLCC) with 20-124 lead counts on .050 inch centers in a “J-Bend” configuration on all package sides
- Leadless Ceramic Chip Carriers (LCCC)
- Leaded Ceramic Chip Carrier (LDCC)
- TapePak®; space-saving tape-automated-bonding process with protective outer ring
- Plastic Pin Grid Arrays (PPGA)
- Plastic Quad Flat Packs (PQFP)

### BOARDS

***“National’s brought its commitment to technical excellence and unmatched reliability to the board level.”***

CMOS INDUSTRIAL MICROCOMPUTER (CIM™)
- digital I/O boards
- memory boards
- software
- systems

MEMORY SYSTEMS

MICROCOMPUTER BOARDS
- analog I/O
- ancillary products
- controller boards
- CPU boards
- digital boards I/O
- expansion modules
- integrated computer module (Series 32000®)
- memory boards

SOFTWARE

### MICROPROCESSOR/ MICROCONTROLLER

***“Only one company has all the solutions to meet all my microprocessor and microcontroller needs: National.”***

MICROPROCESSORS

32-BIT (Series 32000)
- microprocessors (8, 16 & 32-bit interface)
- peripherals
- development systems
- development software
- operating systems (UNIX and real-time)

16-BIT (Bipolar)

F9450

MIL-STD 1750
- peripherals
- development board
- development software

8-BIT (NSC800™ CMOS)
- evaluation board
- microprocessors
- peripherals
- 8-bit development systems

MICROCONTROLLERS

16-BIT (HPC™)
- MOLE™ development system
- terminal management processor (TMP)
- 16-bit microcontroller peripherals
- 16-bit piggyback microcontroller
- 16-bit ROMless microcontrollers
- 16-bit single chip microcontroller

8-BIT (COP800)
- MOLE development system
- terminal management processor
- 8-bit piggyback microcontrollers
- 8-bit ROMless microcontrollers
- 8-bit single chip microcontrollers

4-BIT (COP400)
- MOLE development system
- microwire peripherals MICROWIRE™
- piggyback COPS microcontrollers
- ROMless COPS microcontrollers
- single chip COPS microcontrollers

### ASIC

*"The ASIC decision I make today will greatly affect the success of our products tomorrow. That's why I chose National."*

CUSTOM CIRCUITS
- foundry/customer-owned-tooling
- full custom

SEMI-CUSTOM
- gate array
- standard cell

CMOS AND ECL

TURN-KEY DESIGN

TRAINING PROGRAMS

ON-SITE ENGINEERING ASSISTANCE

FULL SUPPORT OF MAJOR WORKSTATIONS

DOMESTIC/ INTERNATIONAL DESIGN CENTERS

HIGH-VOLUME SIX-INCH PRODUCTION LINE

PROGRAMMABLE LOGIC
- PAL
- FPLAs
- GAL™

### DIGITAL

*"The digital world is rapidly evolving. And, National's keeping pace, with new technologies and a growing product line created to enhance today's systems and tomorrow's ideas."*

LSI/VLSI CMOS
- clocks
- oscillators/dividers
- real time clocks

FAST®

FACT™

F100K ECL

54/74 LOGIC

74ALS ADVANCED LOW-POWER SCHOTTKY

74AS ADVANCED SCHOTTKY

54C/74C CMOS

54HC/74HC HIGH-SPEED CMOS

54LS/74LS LOW-POWER SCHOTTKY

54S/74S SCHOTTKY

CD4000 SERIES

### LINEAR

*"We may be in the middle of a digital revolution, but my designs require linear. And National comes through."*

CONSUMER CIRCUITS
- audio
- automotive
- radio
- temperature sensors
- video

CONVERTERS
- analog to digital
- digital to analog

AMPLIFIERS
- buffers
- instrumentation
- operational
- power
- transconductance servo
- video

ANALOG SWITCHES
- combined function analog
- standard analog

DISCRETE DEVICES
- JFETS
- N-channel
- P-channel
- NPN transistors
- PNP transistors
- diodes
- rectifiers
- MOSFET power

FILTERS
- switched capacitor

FREQUENCY SYNTHESIS
- phase locked loop frequency synthesizers

MOTOR CONTROLLERS
- H-switch
- servo-controllers

SAMPLE AND HOLD
- high speed
- standard

SPECIAL ANALOG FUNCTIONS

TELECOMMUNICATIONS CIRCUITS
- modems
- ISDN
- SLIC
- COMBO™ CIRCUITS
- Codecs
- filters
- dialers

VOLTAGE REFERENCES
- adjustable
- fixed
- precision

VOLTAGE REGULATORS
- dual tracking
- switch mode
- 3-terminal

### MEMORY

*"I want a memory device I can depend on. National makes that happen, applying the highest quality control standards to every phase of development. The result is superior products."*

STANDARD PROGRAMMED CONTROLLERS

EEPROMS

PROMS
- TTL
- ECL

EEPROM CMOS/NMOS

CMOS EPROM

RAMS
- TTL
- ECL
- FIFOs
- MOS static
- BiCMOS

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National Semiconductor is committed to offering you the most comprehensive selection of high-quality, advanced IC products and support to help you meet the ever-changing demands of your marketplace.

The master selection guide provides you with basic features and specifications on National's standard and semi-custom products. Many product families are available in surface-mountable packages and in various military screening flows.

The guide also includes a listing of sources for more detailed information on individual products.

If you have questions, please contact your local National sales office.

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## Section 1

# 1987 Selection Guide for National Products

- Advanced Peripherals
- Application Specific ICs
- Interface
- Linear
- Logic
- Memory
- Microcontrollers
- Microprocessors
- Programmable Logic
- Telecommunications
- Military/Aerospace
- Packaging

# TRADEMARKS

## National Semiconductor Corporation

Abuseable™
Anadig™
ANS-R-TRAN™
Auto-Chem Deflasher™
BI-FET®
BI-FET II™
BI-LINE™
BiPLAN™
BLC™
BLX™
CheckTrak™
CIM™
CIMBUS™
Clock✓Chek™
COMBO™
COPS™
Datachecker®
DENSPAK™
DIB™
Digitalker®
DISCERN™
DNR®
DPVM™
ELSTAR™
E-Z-LINK™
5-Star Service™
HANDISCAN™
GENIX™
HAMR™
HEX3000™
HPC™
ICM™
INFOCHEX™
Integral ISE™
Intelisplay™
ISE™
ISE/80™
ISE/16™
ISE/32™
KeyScan™
LMCMOS™
M$^2$CMOS™
Macrobus™
Macrocomponent™
Meat✓Chek™
MICROBUS®
MICRO-DAC™
µtalker™
Microtalker™
MICROWIRE™
MICROWIRE/PLUS™
MOLE™
MST™
National Semiconductor®
National Semiconductor Corporation® (brand)
NAX800™
Nitride Plus™
Nitride Plus Oxide™
NML™
NOBUS™
NS™
NSCISE™
NSX-16™
NS-XC-16™
NSC800™
NTERCOM™
NURAM™
OXISS™
P$^2$CMOS™
Pharma✓Chek™
PLAN™
Polycraft™
POSitalker™
Power + Control™
QUAD3000™
QUIKLOOK™
RAT™
SABR™
Script✓Chek™
Series/800™
Series 3000™
Series 32000®
Shelf✓Chek™
SPIRE™
STAR®
Starlink™
SuperChip™
SuperScript™
SYS32™
TapePak™
TDS™
Telegate™
The National Anthem®
Time✓Chek™
TINA™
TLC™
Trapezoidal™
TRI-CODE™
TRI-POLY™
TRI-SAFE™
TRI-STATE®
VIP™
XMOS™
XPU™
ZSTAR™
883B/RETS™
883S/RETS™

## Commonly Used Trademarks of Other Companies

**Apple Computer**
Macintosh™

**AT&T**
TOUCH-TONE®
UNIX™

**CBS Labs**
CX™

**Digital Equipment Corporation**
DEC™
Digital™
LSI-11 Series™
MicroPDP-11™
MicroVAX I™
PDP-11™
Q-BUS™
Unibus™
VAX™
VMS™

**Digital Research Corporation**
CP/M®

**Dolby Labs**
Dolby®

**DuPont**
Mylar®
Teflon®

**Intel Corporation**
ICE™
ICS™
Intellec™
MCS™
MULTIBUS®

**International Business Machines Corporation**
FutureNet™
IBM®
IBM PC®

**MicroSoft Corporation**
MS-DOS™
XENIX™

**Monolithic Memories Incorporated**
PAL®
PALASM™
Skinny DIP™

**Opus Systems**
Personal Mainframe™

**Xerox Corporation**
Ethernet™

**Zilog Corporation**
Z80®
Z80A®
Z80B®
Z8000®
Z80000®

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## Life Support Policy

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

**National Semiconductor Corporation** 2900 Semiconductor Drive, P.O. Box 58090, Santa Clara, California 95052-8090 (408) 721-5000 TWX (910) 339-9240

National does not assume any responsibility for use of any circuitry described , no circuit patent licenses are implied, and National reserves the right, at any time without notice, to change said circuitry or specifications.

# Advanced Peripherals

For additional Advanced Peripheral products, see page 407.

# High Speed Serial Data Communications

## IBM and Non-IBM Hierarchical Star or Polling Bus Topologies

As the requirements of distributed data communications have evolved and become more complex, the demand for a more sophisticated transmitting and receiving function has grown rapidly. Most approaches are designed for the transfer and receipt of varying size blocks of data at relatively high data rates coupled with a high degree of data integrity.

One mode of interconnect is the classic point-to-point, deterministic connection between network nodes, and its derivatives, typically between host controllers and their attached peripherals.

### Point-to-Point Communications

In support of advanced point-to-point requirements, National Semiconductor pioneered and introduced the now defacto industry standard DP8340 family of LSI devices which perform high-speed, parallel-to-serial and serial-to-parallel transmit/encoding and receive/decoding. The DP8340/DP8341 pair manage the encoding/decoding function for high speed serial communication which conforms to the protocol defined by the IBM 3270 information display system standard.

The DP8340 generates a 5-bit starting sequence, a 3-bit code violation, a sync bit and a 10-bit data packet—plus a parity bit. Finally, a 3-bit ending code is generated to signal the receiving end of a transmission that the transfer has terminated. The DP8342 performs a similar function—the encoding of parallel data for 8-bit per byte data transfers.

The 10-bit DP8341 and 8-bit DP8343 receivers are the companion components for the DP8340 and DP8342 respectively, and both provide the complete decoding of high speed serial communications. The DP8341 and DP8343 receive the biphase serial data and convert it into ten or eight bits of parallel data respectively.

The DP8340/41 transmit and receive data packets at 2.3587 mb/s. The DP8342/43 support data rates up to 3.5 mb/s.

These chips also feature:

- Single or multibyte data transfers
- Error detection and error type definition on all data transfers
- Internal even or odd parity generation
- Data holding registers
- An automatic clear status function for reduced CPU loading
- An internal crystal-controlled oscillator for all timing requirements

Another significant consideration in the selection of communication devices is the need to transfer data to varying working environments. In many instances, data in the relatively noiseless office setting must be relayed to the much noisier industrial environment. While standard coax cable may be appropriate for the office environment, fiber optics may be called for in the workshop setting. Fiber optics provide a transmission medium which is immune to the EMI generated in the industrial manufacturing environment. As Figure 1 illustrates, the DP8340 family of devices has been designed to communicate over all major media options—coaxial, twisted pair, fiber optic, etc.

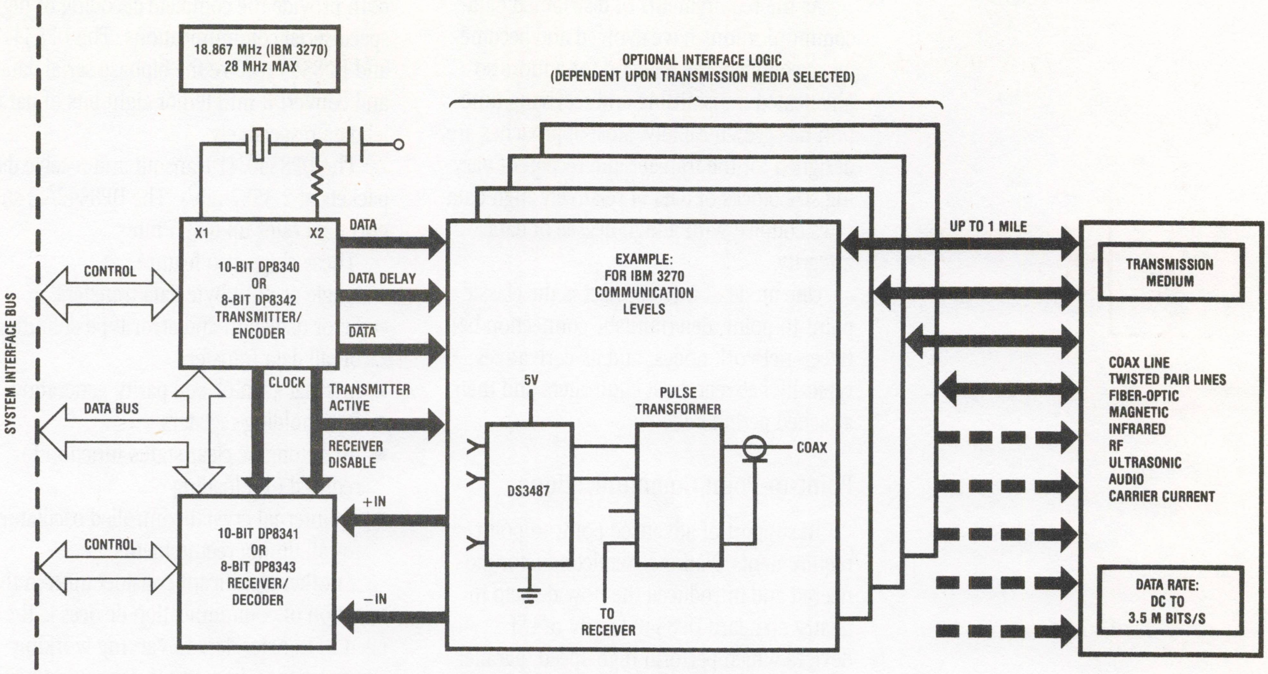

SYSTEM INTERFACE BUS
18.867 MHz (IBM 3270)
28 MHz MAX
X1
X2
CONTROL
10-BIT DP8340
OR
8-BIT DP8342
TRANSMITTER/
ENCODER
DATA
DATA DELAY
$\overline{\text{DATA}}$
CLOCK
TRANSMITTER
ACTIVE
DATA BUS
RECEIVER
DISABLE
+IN
CONTROL
10-BIT DP8341
OR
8-BIT DP8343
RECEIVER/
DECODER
−IN
OPTIONAL INTERFACE LOGIC
(DEPENDENT UPON TRANSMISSION MEDIA SELECTED)
EXAMPLE:
FOR IBM 3270
COMMUNICATION
LEVELS
5V
PULSE
TRANSFORMER
DS3487
COAX
TO
RECEIVER
UP TO 1 MILE
TRANSMISSION
MEDIUM
COAX LINE
TWISTED PAIR LINES
FIBER-OPTIC
MAGNETIC
INFRARED
RF
ULTRASONIC
AUDIO
CARRIER CURRENT
DATA RATE:
DC TO
3.5 M BITS/S

**Figure 1. DP8340 Family Media Support Options**

## National's 2nd Generation IBM Protocol Communication Processor

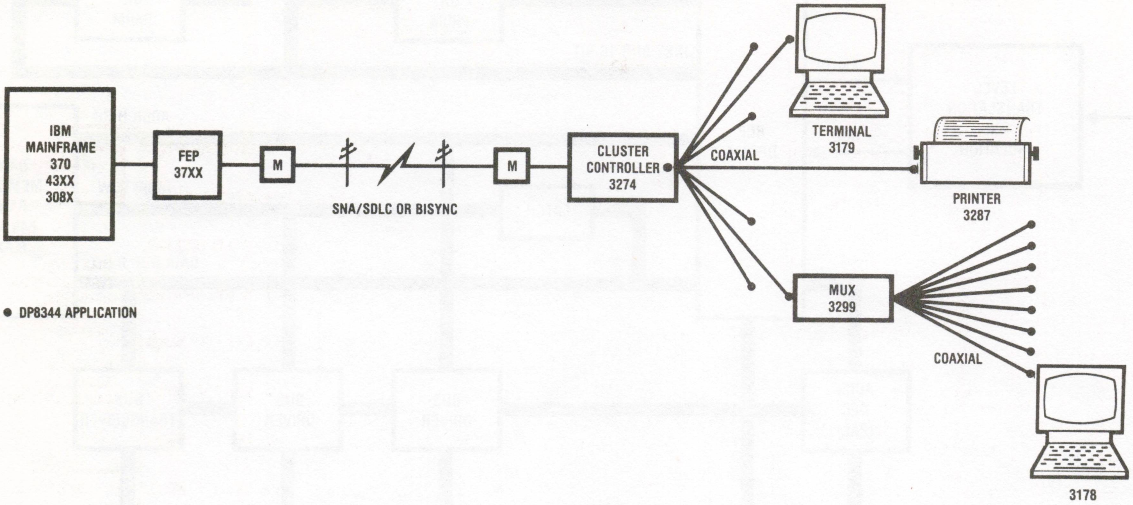
In a traditional IBM 3270 protocol environment, a DP8340/DP8341 chip set would be used in conjunction with a high speed bipolar processor or bit slice approach to execute the peripheral device's response to the polled commands of the IBM 3274 type cluster controller. The polled command response time requirement for the peripheral unit, as specified by IBM, is very fast. This task is usually left to the industry standard 2900 series bit slice devices or the 8X305. These devices, in conjunction with the bipolar DP8340/DP8341 3270 protocol formatter chips and a significant number of miscellaneous logic devices, typically draw well in excess of 1 amp of current, and are limited to servicing polled commands with no overhead processing power left for other system requirements such as keyboard and display functions.

National's 2nd generation release for the IBM 3270 protocol environment is the DP8344V BCP™ Biphase Communications Processor. This new CMOS device integrates a high-speed IBM protocol RISC engine with a front end communications encoder/transmitter-decoder/receiver section which runs at the IBM specified 2.3587 mb/s. The end result is a single 84-pin device which not only replaces the previous generation multichip bipolar solution (thus reducing power consumption and board real estate by a factor of over 10 times) but provides, via its interrupt driven design, up to 80% processing power overhead for other, non-3270 polled response-system requirements. This multitasking processor is very capable of eliminating other support CPUs required in most systems.

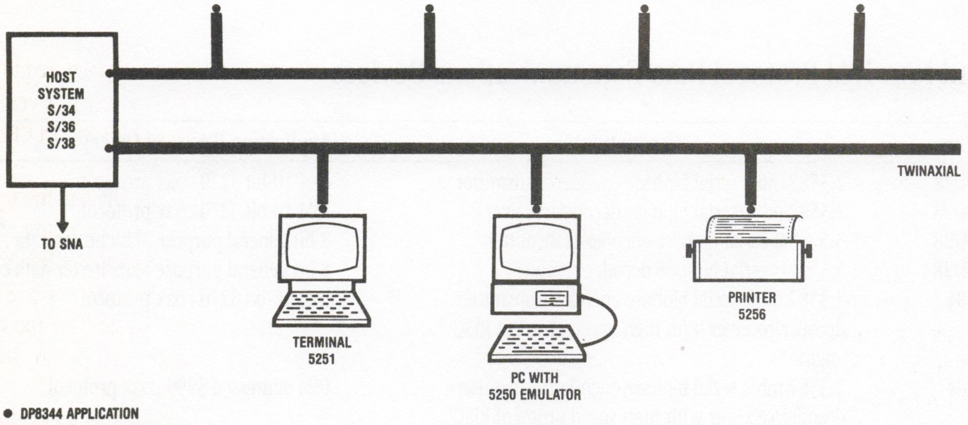
Because the DP8344 incorporates a programmable protocol option transceiver/formatter, it also supports IBM's 3299 coax multiplexer protocol at 2.3587 mb/s and 1 mb/s 5250 "twinax" protocol communications for the sytem 34, 36, 38 departmental processor interface.

The DP8344 is ideally suited for either the controller/system or peripheral interface applications shown in the typical topological system diagrams.

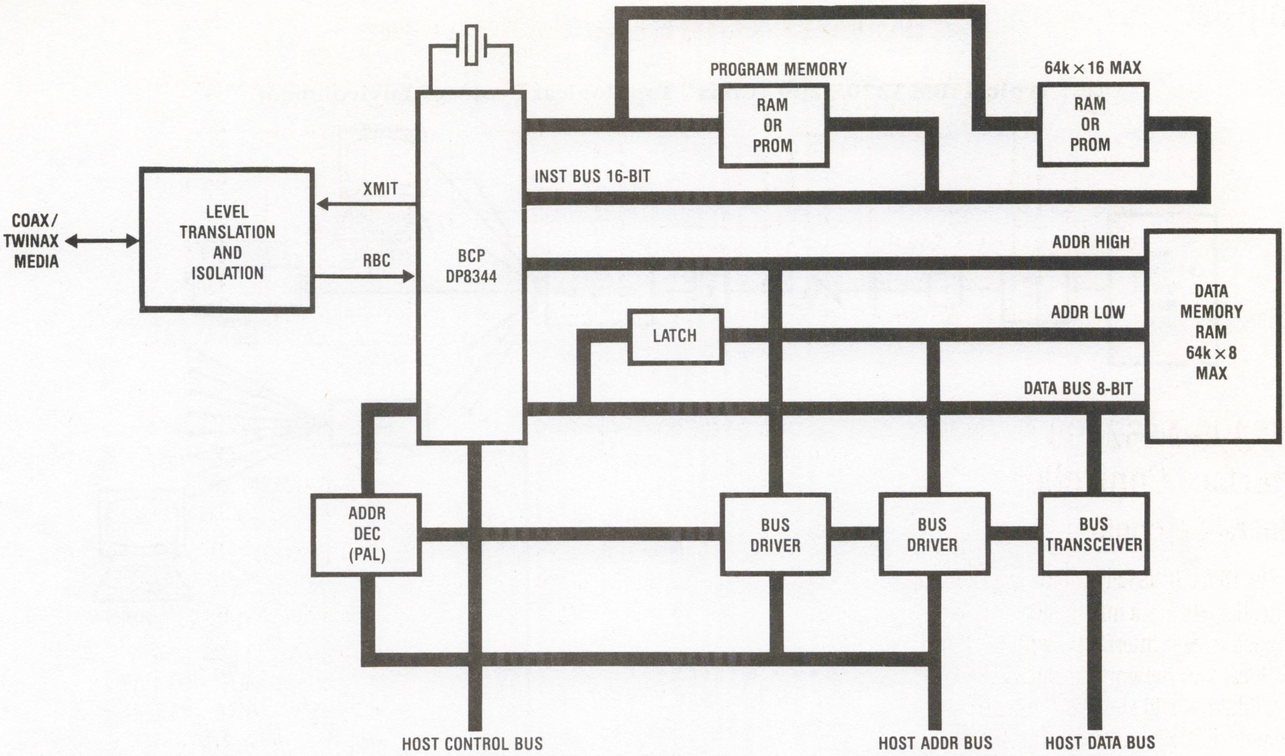
## Typical IBM 3270/3299 "Coax" Topological/Protocol Environment


IBM MAINFRAME 370 43XX 308X
FEP 37XX
M
SNA/SDLC OR BISYNC
M
CLUSTER CONTROLLER 3274
COAXIAL
TERMINAL 3179
PRINTER 3287
MUX 3299
COAXIAL
3178
● DP8344 APPLICATION

## Typical IBM 5250 "Twinax" Topological/Protocol Environment


HOST SYSTEM S/34 S/36 S/38
TO SNA
TWINAXIAL
TERMINAL 5251
PC WITH 5250 EMULATOR
PRINTER 5256
● DP8344 APPLICATION

**DP8344 Implementation for 3270 "Coax", 5250 "Twinax", or 8-Bit General Purpose Systems**

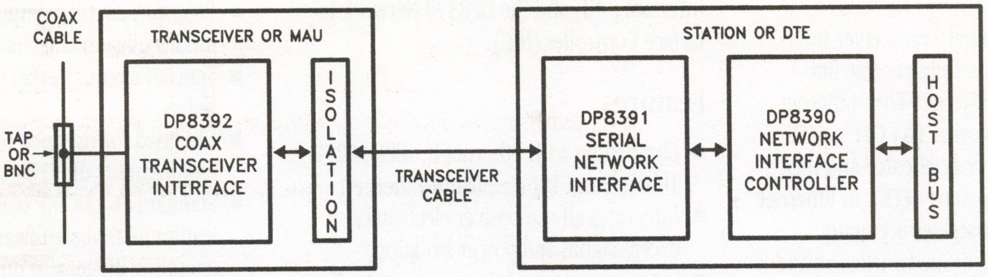

PROGRAM MEMORY
64k × 16 MAX
RAM OR PROM
RAM OR PROM
INST BUS 16-BIT
XMIT
RBC
COAX/ TWINAX MEDIA
LEVEL TRANSLATION AND ISOLATION
BCP DP8344
ADDR HIGH
ADDR LOW
LATCH
DATA MEMORY RAM 64k × 8 MAX
DATA BUS 8-BIT
ADDR DEC (PAL)
BUS DRIVER
BUS DRIVER
BUS TRANSCEIVER
HOST CONTROL BUS
HOST ADDR BUS
HOST DATA BUS

## High Speed IBM and Non-IBM Protocol Data Communications Devices

| Device # | Pins | Description | Application (Physical Layer) |
|---|---|---|---|
| DP8340 N/J/V | 24/28 | 2.3587 mb/s serial biphase encoder/transmitter | IBM 10-bit 3270 coax protocol |
| DP8341 N/J/V | 24/28 | 2.3587 mb/s serial biphase decoder/receiver | IBM 10-bit 3270 coax protocol |
| DP8342 N/J/V | 24/28 | 3.5 mb/s serial biphase encoder/transmitter | 8-bit general purpose Manchester data communication |
| DP8343 N/J/V | 24/28 | 3.5 mb/s serial biphase decoder/receiver | 8-bit general purpose Manchester data communication |
| DP8344 V | 84 | 2.3587 mb/s serial biphase encoder/transmitter-decoder/receiver with high-speed protocol RISC engine | IBM 10-bit 3270 coax protocol |
| DP8344 V | 84 | 2.3587 mb/s serial biphase encoder/transmitter-decoder/receiver with high-speed protocol RISC engine | IBM addressed 3299 coax protocol |
| DP8344 V | 84 | 1.0 mb/s serial biphase encoder/transmitter-decoder/receiver with high-speed protocol RISC engine | IBM 5250 twinax protocol |
| DP8344 V | 84 | 0.1–4.0 mb/s serial biphase encoder/transmitter-decoder/receiver with high-speed protocol RISC engine | 8-bit general purpose Manchester data communication |

# Local Area Network Chip Set

**IEEE 802.3 Compatible Ethernet/Thin-Ethernet**


COAX CABLE
TAP OR BNC
TRANSCEIVER OR MAU
DP8392 COAX TRANSCEIVER INTERFACE
ISOLATION
TRANSCEIVER CABLE
STATION OR DTE
DP8391 SERIAL NETWORK INTERFACE
DP8390 NETWORK INTERFACE CONTROLLER
HOST BUS

## DP8390/NS32490 Network Interface Controller

### General Description

The DP8390/NS32490 Network Interface Controller (NIC) is a microCMOS VLSI device designed to ease interfacing with CSMA/CD type local area networks including Ethernet, Thin/Ethernet and StarLAN™. The NIC implements all Media Access Control (MAC) layer functions for transmission and reception of packets in accordance with the IEEE 802.3 Standard. Unique dual DMA channels and an internal FIFO provide a simple yet efficient packet management design. To minimize system parts count and cost, all bus arbitration and memory support logic are integrated into the NIC.

The NIC is the heart of a three chip set that implements the complete IEEE 802.3 protocol and node electronics as shown above. The other two chips are the DP8391 Serial Network Interface (SNI) and the DP8392 Coaxial Transceiver Interface (CTI).

### Features

- Compatible with IEEE 802.3/Ethernet II/Thin-Ethernet/StarLAN
- Interfaces with 8, 16 and 32-bit microprocessor systems
- Implements simple, versatile buffer management
- Requires single 5V supply
- Utilizes low power microCMOS process
- Includes
  - —Two 16-bit DMA channels
  - —16-byte internal FIFO with programmable threshold
  - —Network statistics storage
- Supports physical, multicast, and broadcast address filtering
- Provides 3 levels of loopback
- Utilizes independent system and network clocks

## DP8391/NS32491 Serial Network Interface

### General Description

The DP8391 Serial Network Interface (SNI) provides the Manchester data encoding and decoding functions for IEEE 802.3 Ethernet/Thin-Ethernet type local area networks. The SNI interfaces the DP8390 Network Interface Controller (NIC) to the Ethernet transceiver cable. When transmitting, the SNI converts non-return-to-zero (NRZ) data from the controller and clock pulses into Manchester encoding and sends the converted data differentially to the transceiver. The opposite process occurs on the receive path, where a digital phase-locked loop decodes 10-Mbit/s signals with as much as ± 20 ns of jitter.

The DP8391 SNI is a functionally complete Manchester encoder/decoder including ECL like balanced driver and receivers, on board crystal oscillator, collision signal translator, and a diagnostic loopback circuit.

The SNI is part of a three chip set that implements the complete IEEE compatible network node electonics as shown above. The other two chips are the DP8392 Coax Transceiver Interface (CTI) and the DP8390 Network Interface Controller (NIC).

### Features

- Compatible with Ethernet II, IEEE 802.3 10base5 and 10base2 (Thin-Ethernet)
- 10 Mb/s Manchester encoding/decoding with receive clock recovery
- Patented digital phase locked loop (DPLL) decoder requires no precision external components
- Decodes Manchester data with up to ± 20 ns of jitter
- Loopback capability for diagnostics
- Externally selectable half or full step modes of operation at transmit output
- Squelch circuits at the receive and collision inputs reject noise
- High voltage protection at transceiver interface (16V)
- TTL/MOS compatible controller interface
- Connects directly to the transceiver (AUI) cable

## DP8392/NS32492 Coaxial Transceiver Interface

### General Description

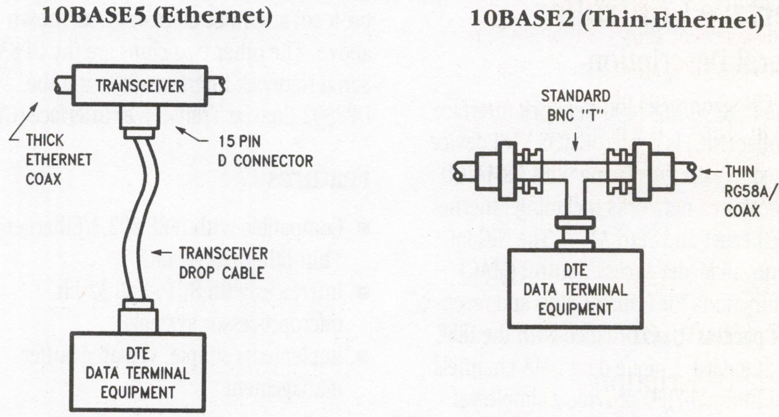
The DP8392 Coaxial Transceiver Interface (CTI) is used as a coaxial cable line driver/receiver for Ethernet/Thin-Ethernet type local area networks. The CTI is connected between the coaxial cable and the Data Terminal Equipment (DTE). In Ethernet applications the transceiver is usually mounted within a dedicated enclosure and is connected to the DTE via a transceiver cable. In Thin-Ethernet applications, the CTI is typically located within the DTE and connects to the DTE through isolation transformers only. The CTI consists of a Receiver, Transmitter, Collision Detector, and a Jabber Timer. The Transmitter connects directly to a 50Ω coaxial cable where it is used to drive the coax when transmitting. During transmission, a jabber timer is initiated to disable the CTI transmitter in the event of a longer than legal length data packet. Collision Detection circuitry monitors the signals on the coax to determine the presence of colliding packets and signals the DTE in the event of a collision.

The CTI is part of a three chip set that implements the complete IEEE 802.3 compatible network node electronics. The other two chips are the DP8391 Serial Network Interface (SNI) and the DP8390 Network Interface Controller (NIC).

### Features

- Compatible with Ethernet II, IEEE 802.3 10base5 and 10base2 (Thin-Ethernet)
- Integrates all transceiver electronics except signal and power isolation
- Innovative design minimizes external component count
- Jabber timer function integrated on chip
- Externally selectable CD Heartbeat allows operation with IEEE 802.3 compatible repeaters
- Precision circuitry implements receive mode collision detection
- Squelch circuitry at all inputs rejects noise
- Designed for rigorous reliability requirements of IEEE 802.3
- Standard 16-pin DIP uses a special leadframe that significantly reduces the operating die temperature

**Typical Connection Diagram for an IEEE 802.3 Node**


**10BASE5 (Ethernet)**
**10BASE2 (Thin-Ethernet)**

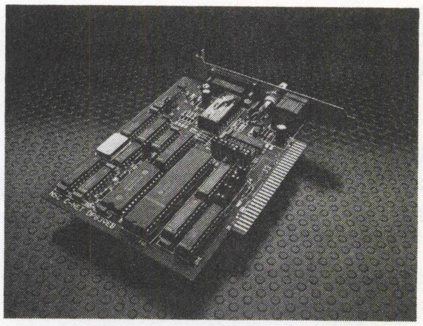
## DP839EB LAN Evaluation Board

### General Description

The National Semiconductor DP839EB Network Interface Adapter (NIA) provides IBM PCs and PC compatibles with Ethernet, Thin-Ethernet and StarLAN connections. The DP839EB is compatible with the PC-bus and requires only a 1/2 size slot for installation. The NIA utilizes National Semiconductor's IEEE 802.3 chip set consisting of the DP8390 Network Interface Controller, the DP8391 Serial Network Interface and the DP8392 Coaxial Transceiver Interface. The DMA capabilities of the DP8390, coupled with 8 kbytes of buffer RAM, allow the Network Interface Adapter to appear as a standard I/O port to the system.

### Hardware Features

- Half-size IBM PC I/O card form factor
- DP8390 Network Interface Controller with DMA
- 8 kbyte on-board multipacket buffer
- Clean DMA interface to IBM-PC
- Ethernet interface via 15-pin D connector
- Thin-Ethernet interface via BNC connector
- StarLAN support with optional daughter card and 8-pin modular phone jack
- Option for driving 3270 93Ω coax
- DP8391 Serial Network Interface
- DP8392 Coaxial Transceiver Interface
- Low power requirement



# Mass Storage/ Disk Drive Support

The National Semiconductor family of mass storage interface products offers the industry the highest performance and broadest range of products for Winchester hard disks and floppy disks.

The disk data undergoes many transformations from the time the flux reversals on the disk platter are read by the head amplifier to the time the data can actually be used by the host system—whether it's a PC or main frame computer. With the exception of the preamplifier, National offers a complete integrated solution for this data path. Concentrating only on the data path portion of the disk system allows National to offer solutions for integration that are totally independent of the type of interface used. Shown in Figure 1 is a block diagram of a typical disk system. The first device in the data path is the pulse detector.

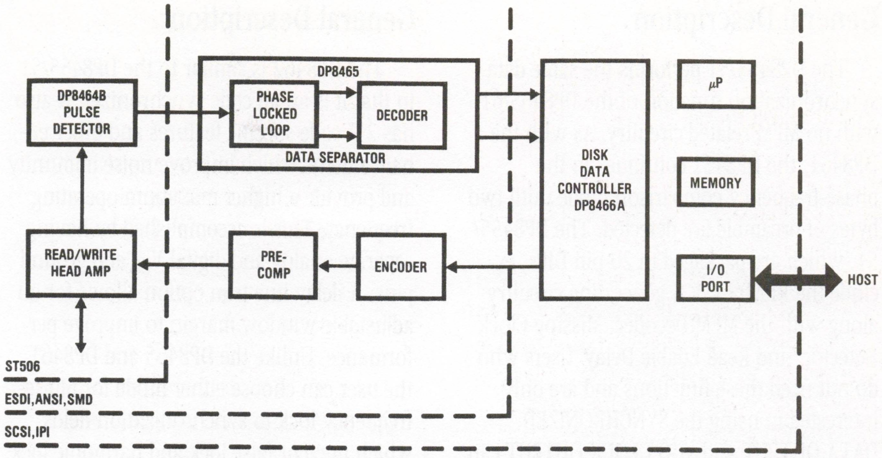


**Figure 1. Typical Disk Drive Data Path**

# DP8464B Disk Pulse Detector

## General Description

The DP8464B Disk Pulse Detector utilizes analog and digital circuitry to detect amplitude peaks of the signal received from the read/write amplifier of a disk head. The DP8464B produces a TTL compatible output which, on the positive leading edge, indicates a signal peak. Electrically, these peaks correspond to flux reversals on the magnetic medium. The signal from the read/write amplifier when reading a disk is, therefore, a series of pulses with alternating polarity. The disk pulse detector accurately replicates the time position of these pulse peaks.

The pulse detector is fabricated using an advanced oxide isolated Schottky process, and has been designed to function with data rates up to 15 Mbits/s. The DP8464B is available in either a 300 mil wide 24-pin dual-in-line package or a surface mount 28-pin plastic chip carrier (PCC).

## Features

- Wide input signal amplitude range—from 20 mVpp to 660 mVpp
- Data rates up to 15 Mbits/s 2,7 code or 10 Mbits/s MFM
- On-chip differential gain controlled amplifier, differentiator, comparator gating circuitry, and output pulse generator
- Adjustable comparator hysteresis
- AGC and differentiator time constants set by external components

# DP8465/61 Data Separator

## General Description

The DP8465/61 Data Separators are designed for applications in disk drive memory systems, and depending on system requirements, may be located either in the drive or in the controller. They receive digital pulses from a pulse detector circuit (such as the DP8464B) if situated in the drive, or from an ST506 interface if situated in the controller. After locking to the frequency of these input pulses, they separate them into synchronized data and clock signals. While in the non-read mode, both of these circuits employ a phase-frequency comparator to keep the VCO locked to the 2F input (this signal may be derived from a crystal or a servo track). The DP8465 switches to a phase-only comparator when the read mode is entered. The DP8461 continues to use a phase-frequency comparator until the preamble detection circuit has detected two bytes of preamble. This feature thus restricts the DP8461 to use with codes employing the 1010 preamble. MFM and certain run length limited (RLL) codes such as 1,7 and 1,8 employ such a preamble. If RLL code is used or if the user wishes to do his own data separation, the synchronized data output is available to allow external circuitry to perform the data decoding function.

## DP8455/51 Data Synchronizer

### General Description

The DP8455/51 performs the same data synchronization function of the DP8465/61 with no MFM related circuitry. As with the DP8461, the DP8451 continues in the phase-frequency comparison mode until two bytes of preamble are detected. The DP8455/51, which are packaged in 20-pin DIPs, exclude the READ CLOCK generating circuitry along with the MFM Decoder, Missing Clock Detector, and Read Enable Delay. Users who do not need these functions and are only interested in using the SYNCHRONIZED DATA OUTPUT and VCO CLOCK OUTPUT can use the DP8455/51 as alternatives to the DP8465/61.

## DP8462 2,7 Data Synchronizer

### General Description

The DP8462 is similar to the DP8455/51 in that it is an all code synchronizer. It also has 2,7 code specific features and other enhancements which improve noise immunity and provide a higher maximum operating frequency. This is accomplished by having separate analog and digital $V_{CC}$ and ground pins. A delay line trim option allows for an adjustable window margin to improve performance. Unlike the DP8465 and DP8461, the user can choose either mode for phase-frequency lock to synchronization fields which prevent false lock and harmonic lock.

### Features

- Phase-frequency comparison in non-read mode (DP8465/55)
- Phase-frequency comparison in preamble (DP8461/51)
- 4-byte preamble-lock indication capability
- User-determined PLL loop filter network
- Standard narrow 24-pin DIP, 28-pin PCC (DP8465/61/62) or 20-pin DIP, 20-pin PCC (DP8455/51)

## DP8463B 2,7 Endec

### General Description

To complete the 2,7 data separating function, National offers the DP8463B 2,7 Endec. The 2,7 Endec performs the encoding and decoding for run length limited (RLL) codes for disk memory systems. When compared to MFM code, 2,7 gives a disk system the ability to record up to 50% more message data in the same media space without any increase in the flux density or flux changes per inch (FCI). The DP8463 also performs other functions of writing or reading format segments that can not be done by a disk data controller. These additional functions include the writing and reading of various address marks and preambles (PLL synchronization fields) that are compatible with RLL code. The user may also select different lengths of preamble to count before the DP8463B issues a lock detect signal.

The DP8463B is compatible with the Storage Module Drive (SMD) and Enhanced Small Device Interface (ESDI) functional specifications and has a format mode similar to the one used in ST506 devices.

### Features

- Encodes and decodes using IBM 2,7 Message/Code Table
- Programmable formats
  Hard sector, soft sector with address mark preceding preamble, soft sector with address mark following preamble
- Programmable address marks
- Glitchless multiplexer is used to switch between read/reference clock sources
- Programmable preamble length counted before lock detected signal is issued
- Message data rate to 20 Mbits/sec
- 2-micron dual metal CMOS

# DP8466A Disk Data Controller

## General Description

The DP8466A Disk Data Controller (DDC) is an intelligent peripheral which interfaces Winchester or floppy disk drives to microprocessor based systems. It transfers data between a buffer memory or host system and the serial bit data stream with disk rates up to 25 Mbits/sec. High speed system data transfer is possible with full on-chip DMA control of buffer or main memory. The 16-bit system I/O interface allows use with any popular 8-bit, 16-bit, or 32-bit microprocessor. Programmable track format enables reconfiguration of the DDC for different drive types in a multiple drive environment. Using other National DP8460 series disk data path chips, the DP8466A conforms to ST506, SMD and ESDI standard drive interfaces, as well as to intelligent standard interfaces such as SCSI (SASI) and IPI. The DDC is available in three performance versions: DP8466AN-12, DP8466AN-20, and DP8466AN-25.

## Features

- Easily conforms to any standard drive interface
- Compatible with floppy, hard and optical disk drives
- Compatible with 8, 16, 32-bit microprocessor systems
- Programmable disk format
- Sector lengths up to 64 kbytes, with up to 255 sectors per track
- Programmable 32 or 48-bit ECC polynominal
- Internal ECC correction in less than a sector time
- Disk data rate to 25 Mbits/sec
- Multiple sector transfer capability
- 32-byte internal FIFO data buffer with interleavable burst capability
- 8 or 16-bit wide data transfers
- Single 32-bit or dual 16-bit DMA channel addresses
- Up to 10 Mbits/sec DMA transfer rate

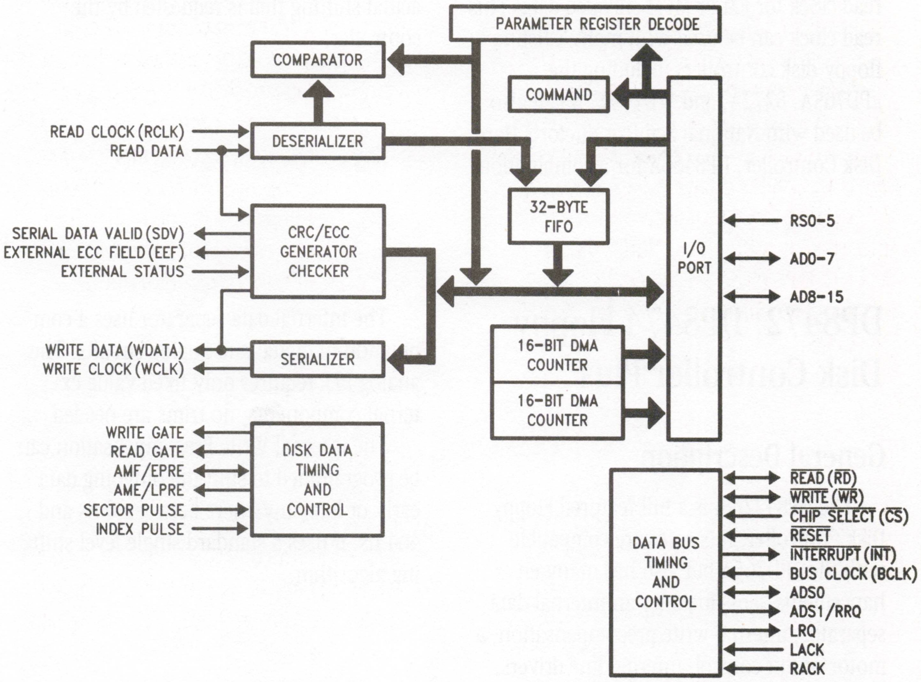

PARAMETER REGISTER DECODE
COMPARATOR
COMMAND
READ CLOCK (RCLK)
READ DATA
DESERIALIZER
32-BYTE FIFO
I/O PORT
RS0-5
AD0-7
AD8-15
SERIAL DATA VALID (SDV)
EXTERNAL ECC FIELD (EEF)
EXTERNAL STATUS
CRC/ECC GENERATOR CHECKER
WRITE DATA (WDATA)
WRITE CLOCK (WCLK)
SERIALIZER
16-BIT DMA COUNTER
16-BIT DMA COUNTER
WRITE GATE
READ GATE
AMF/EPRE
AME/LPRE
SECTOR PULSE
INDEX PULSE
DISK DATA TIMING AND CONTROL
DATA BUS TIMING AND CONTROL
READ (RD)
WRITE (WR)
CHIP SELECT (CS)
RESET
INTERRUPT (INT)
BUS CLOCK (BCLK)
ADS0
ADS1/RRQ
LRQ
LACK
RACK

**Figure 2. Disk Data Controller (DDC)**

# DP8470 Floppy Disk Support Chip Data Separator and Write Precompensation

## General Description

The DP8470 is a general purpose data separator which can be used to generate a read clock for FM or MFM encoded data. This read clock can be used with many existing floppy disk controllers including the μPD765A, 8272A, and WD179X. It can also be used with National Semiconductor's Hard Disk Controller, DP8466A for a combination hard disk/floppy disk system. The data separator can be used for data rates ranging from 125 kbits/sec up to 1.25 Mbits/sec.

The DP8470 also contains a write precompensation circuit. Normally a disk controller will determine whether a bit of data needs to be shifted early, late, or not at all. The controller does not do the actual shifting however. The DP8470 will do the actual shifting that is requested by the controller.

## Features

- Analog PLL data separator
- Write precompensation (0 ns–393 ns)
- Requires no external trimmable components
- Supports FM/MFM 125 kbits/sec to 1.25 Mbits/sec
- Interface to all popular floppy disk controllers
- 24-pin narrow package or 28-pin PCC

# DP8472, DP8474 Floppy Disk Controller Plus

## General Description

The DP8472/74 is a full featured Floppy Disk Controller. It is software compatible with the μPD765A but also has many enhancements. This includes an internal data separator, internal write precompensation, a motor on/off control, internal line drivers, low power mode, and some software enhancements that simplify programming the DP8472/74.

The internal data separator uses a combination of digital and analog circuits. The analog PLL requires only fixed value external components, no trims are needed.

The internal Write Precompensation can be programmed to shift the outgoing data early or late, anywhere between 0 ns and 464 ns. It uses a standard single level shifting algorithm.

## Features

- Internal dual gain, analog data separator
- Internal write precompensation
- Software compatible with the μPD765A/8272A
- Software selectable data rate (125 kbits/sec to 2.5 Mbits/sec)
- No trimmable passive components needed
- Extended track range (up to 4096 tracks)
- 40-pin DIP or 44-pin PCC

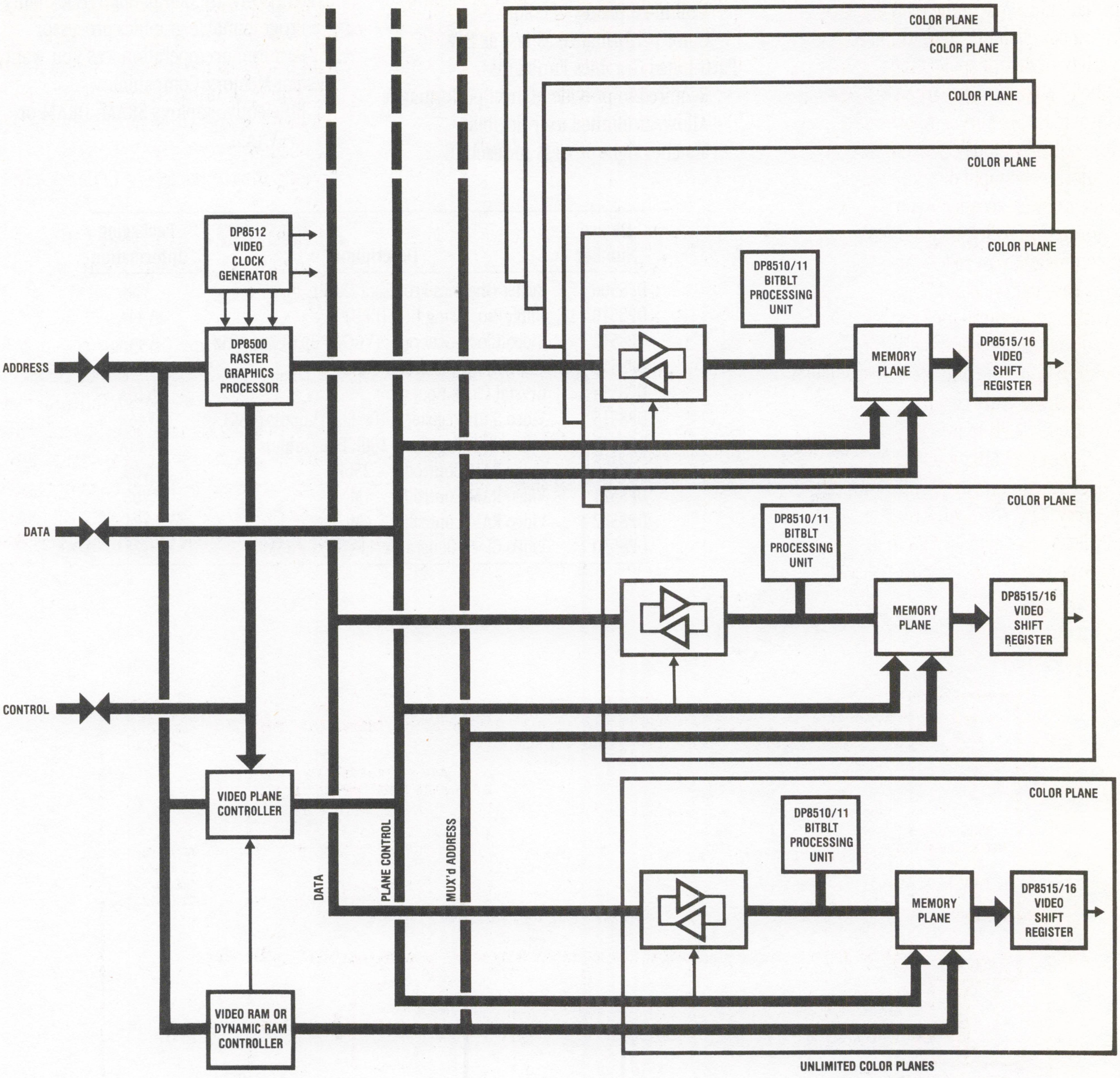
# Graphics

## Advanced Graphics Chip Set Offers:

- Highest Graphics Performance in the Industry
  - Resolutions to 16k × 16k
  - Unlimited planes of color
  - Color performance as fast as B/W
- Partitioned Graphics Functions
  - Required to provide highest performance
  - Allows unlimited user flexibility
  - Matches right process for each IC
- Open Architecture
  - Easy/cost effective system design
  - Performance flexibility
  - Allows use of the host CPU to help
  - Allows growth in the family
- System Software Compatibility/Flexibility
  - Programmable graphics processor
  - Performance/operation "as you want it"
- System Memory Compatibility
  - Efficiently employs SRAM, DRAM or VRAM

| Device Number | Description | Packaging Information |
|---|---|---|
| DP8500 | Raster Graphics Processor (RGP) | V68 |
| DP8510/11 | Bitblt Processing Unit (BPU) | V44A |
| DP8512 | Video Clock Generator (VCG) – up to 225 MHz | V44A |
| DP8513 | Video Clock Generator Slave | V44A |
| DP8514 | Crystal Clock Generator | N16A |
| DP8515 | Video Shift Register – 10k ECL Outputs (VSR) | V44A |
| DP8516 | Video Shift Register – 100k ECL Outputs | V44A |
| DP8520 | Video RAM Controller – 256k | V68 |
| DP8521 | Video RAM Controller – 1M | V68 |
| DP8522 | Video RAM Controller – 4M | V84 |
| DP8530 | Video Clock Generator (LFVCG) – 125MHz | V28 |

## Advanced Graphics Chip Set


COLOR PLANE
COLOR PLANE
COLOR PLANE
COLOR PLANE
COLOR PLANE
DP8512 VIDEO CLOCK GENERATOR
DP8510/11 BITBLT PROCESSING UNIT
ADDRESS
DP8500 RASTER GRAPHICS PROCESSOR
MEMORY PLANE
DP8515/16 VIDEO SHIFT REGISTER
DATA
COLOR PLANE
DP8510/11 BITBLT PROCESSING UNIT
MEMORY PLANE
DP8515/16 VIDEO SHIFT REGISTER
CONTROL
VIDEO PLANE CONTROLLER
COLOR PLANE
DP8510/11 BITBLT PROCESSING UNIT
DATA
PLANE CONTROL
MUX'd ADDRESS
MEMORY PLANE
DP8515/16 VIDEO SHIFT REGISTER
VIDEO RAM OR DYNAMIC RAM CONTROLLER
UNLIMITED COLOR PLANES

# Memory Support

## The DP8400 Family

In National Semiconductor's quest to provide a complete solution to the increasing variety of design applications, an extensive line of memory support peripherals are now provided. Memory support can prove to be most critical in today's memory intensive applications. The rapid development in dynamic random access memory (DRAM) chip storage capability, coupled with significant component cost reductions, has allowed designers to build large memory arrays with high performance specifications. National's current generation of DRAM controller/drivers are the only devices available today which are truly capable of delivering ''no-waitstate'' CPU to memory accessing at and well above 10 MHz while driving 8 Mbytes of system memory, plus EDAC check bit memory. And you won't require the fastest/most expensive DRAMs to achieve this new performance standard either. The DP8420, DP8421 and DP8422 next generation 256 kbit, 1 Mbit and 4 Mbit DRAM controller/drivers will take this performance standard one step further by offering no-waitstate accessing capability via low power CMOS, a truly single chip solution including fully programmable microprocessor specific interface logic, dual CPU porting, byte write capability, and on-board direct drive capable of directly addressing up to 64 Mbytes of system memory from a single DRAM controller/driver.

Today's large DRAM arrays require sophisticated high performance devices to provide timing and control. National offers the broadest range of DRAM contollers with the highest performance available on the market. Controllers are available for DRAMs from 64 kbit through 4 Mbit devices, supporting memory arrays up to 64 Mbytes in size. For critical applications, National has developed several Error Checking and Correction (ECC) devices to provide maximum data integrity.

The DP8400 DRAM interface family provides complete solutions to memory support (Figure 1). This begins with the LSI functions such as the DP8402A 32-bit error detector/corrector and the DP8429 1 Mbit DRAM controller/driver. It continues with the DP84240 and the DP84244 high performance buffer/drivers. Finally it concludes with easy interface to popular microprocessors with the use of the DP84XX2 series. It is the first family of DRAM support circuits designed for universal applications with multiple microprocessors, with the versatility to support all manufacturers' CPUs equally.

## The DP8400 Family of Full Function DRAM Controller/Drivers

The heart of any DRAM array design is the controller function. Previous LSI controllers supplied a minimum function of address multiplexing with an on-board refresh counter. This required external delay line timing and logic to control memory access, additional logic to perform memory refresh, and external drivers to drive the capacitive

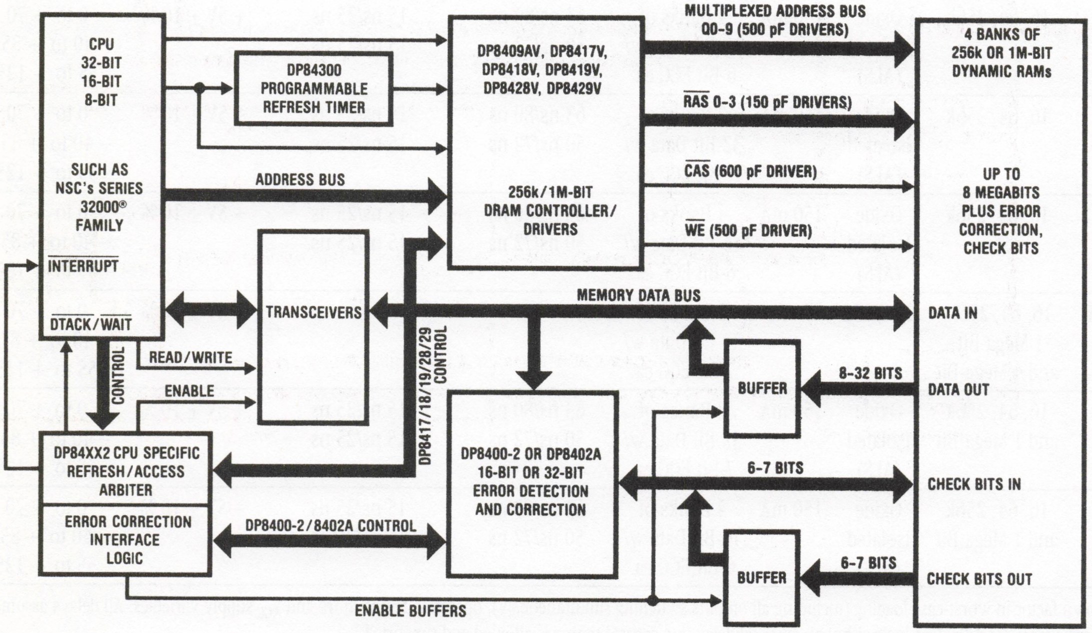

CPU
32-BIT
16-BIT
8-BIT
SUCH AS
NSC's SERIES
32000®
FAMILY
INTERRUPT
DTACK/WAIT
CONTROL
READ/WRITE
ENABLE
DP84300
PROGRAMMABLE
REFRESH TIMER
ADDRESS BUS
TRANSCEIVERS
DP8409AV, DP8417V,
DP8418V, DP8419V,
DP8428V, DP8429V
256k/1M-BIT
DRAM CONTROLLER/
DRIVERS
MULTIPLEXED ADDRESS BUS
Q0-9 (500 pF DRIVERS)
RAS 0-3 (150 pF DRIVERS)
CAS (600 pF DRIVER)
WE (500 pF DRIVER)
4 BANKS OF
256k OR 1M-BIT
DYNAMIC RAMs
UP TO
8 MEGABITS
PLUS ERROR
CORRECTION,
CHECK BITS
MEMORY DATA BUS
DATA IN
DP8417/18/19/28/29
CONTROL
BUFFER
8-32 BITS
DATA OUT
DP84XX2 CPU SPECIFIC
REFRESH/ACCESS
ARBITER
DP8400-2 OR DP8402A
16-BIT OR 32-BIT
ERROR DETECTION
AND CORRECTION
6-7 BITS
CHECK BITS IN
ERROR CORRECTION
INTERFACE
LOGIC
DP8400-2/8402A CONTROL
BUFFER
6-7 BITS
CHECK BITS OUT
ENABLE BUFFERS

**Figure 1. DP8400 Family—The Complete Solution for Fast, Error Free Dynamic Memory Interface**

memory array. The complete solution results in significant access delay in relations to DRAM speeds and skews in output sequencing, as well as a large component count.

National's LSI DRAM controllers (Table 1) have brought much of this logic on-chip. These devices provide the flexibility of external access control, along with automatic access timing generation, without the need for an external timing generator clock. In addition, on-board capacitive drivers allow direct drive in excess of 500 pF, or the equivalent of over 88 DRAMs.

The data below is intended to highlight the key differentiable features of each DRAM Controller/Driver offered by National Semiconductor. All NSC DRAM controllers integrate on-board delay line timing, high capacitive drive, row/column muxing logic, refresh counting, row and column input latching and memory bank select logic. Because of the family feature commonality, most devices offer pin for pin up/downward compatibility; however, process and design differences between devices result in a broad selection of feature and performance options for the best system fit.

## Error Correction

The DP8400-2 expandable error checker/corrector offers a high degree of flexibility in applications which range from 8-bit to 80-bit data words. It is a 16-bit chip that is easily expandable with the simple addition of more DP8400s for each 16-bit word increment.

In addition to the popular DP8400-2 16-bit error checker/corrector, National offers a 32-bit Error Detector and Corrector (EDAC). With a few exceptions, the DP8402A is functionally similar to the DP8400-2. One major exception is that the DP8402A is not expandable beyond 32-bits.

**Table 1. DRAM Controller Master Selection Guide**

| | | | | | Max RAS to CAS Out | | Guaranteed Row Address Hold | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Device # and Speed Options | DRAMS Supported | Process | Typ $I_{CC}$ | A.C. Specified Word Width | *Fast Mode | Slow Mode | *Fast Mode | Slow Mode | $V_{CC}$ | Operating Temp Range (°C) | Package |
| DP8408A<br>A-2<br>A-3 | 16, 64k | Junction Isolated (S) | 210 mA | 4 Banks of 16-Bit Data w/ 6-Bit ECC ea. | 105 ns/125 ns<br>85 ns/100 ns<br>120 ns/145 ns | | 20 ns/30 ns<br>12 ns/20 ns<br>20 ns/30 ns | | + 5V ± 5% | 0 to + 70<br>0 to + 85 | 48N<br>48D |
| DP8409A<br>A-2<br>A-3 | 16, 64, 256k | Junction Isolated (S) | 210 mA | 4 Banks of 16-Bit Data w/ 6-Bit ECC ea. | 105 ns/125 ns<br>85 ns/100 ns<br>120 ns/145 ns | | 20 ns/30 ns<br>12 ns/20 ns<br>20 ns/30 ns | | + 5V ± 5% | 0 to + 70<br>0 to + 85 | 48N<br>48D<br>68V |
| DP8417-80<br>-70 | 16, 64, 256k | Oxide Isolated (ALS) | 150 mA | 4 Banks of 16-Bit Data w/ 6-Bit ECC ea. | 63 ns/80 ns<br>50 ns/72 ns | | 15 ns/25 ns<br>15 ns/25 ns | | + 5V ± 10% | 0 to + 70<br>− 40 to + 85<br>− 55 to + 125 | 48N<br>48D<br>68V |
| DP8418-80<br>-70 | 16, 64, 256k | Oxide Isolated (ALS) | 150 mA | 2 Banks of 32-Bit Data w/ 7-Bit ECC ea. | 63 ns/80 ns<br>50 ns/72 ns | | 15 ns/25 ns<br>15 ns/25 ns | | + 5V ± 10% | 0 to + 70<br>− 40 to + 85<br>− 55 to + 125 | 48N<br>48D<br>68V |
| DP8419-80<br>-70 | 16, 64, 256k | Oxide Isolated (ALS) | 150 mA | 4 Banks of 16-Bit Data w/ 6-Bit ECC ea. | 63 ns/80 ns<br>50 ns/72 ns | | 15 ns/25 ns<br>15 ns/25 ns | | + 5V ± 10% | 0 to + 70<br>− 40 to + 85<br>− 55 to + 125 | 48N<br>48D<br>68V |
| DP8420, DP8421 and DP8422 | 16, 64, 256k, 1 Mega-Bit, and 4 Mega-Bit | 2μ CMOS | 5 mA | 2 Banks of 32-Bit Data w/ 7-Bit ECC ea. | — | | — | | + 5V ± 10% | 0 to + 70<br>− 40 to + 85<br>− 55 to + 125 | 68V<br>84V |
| DP8428-80<br>-70 | 16, 64, 256k and 1 Mega-Bit | Oxide Isolated (ALS) | 150 mA | 2 Banks of 32-Bit Data w/ 7-Bit ECC ea. | 63 ns/80 ns<br>50 ns/72 ns | | 15 ns/25 ns<br>15 ns/25 ns | | + 5V ± 10% | 0 to + 70<br>− 40 to + 85<br>− 55 to + 125 | 52D<br>68V |
| DP8429-80<br>-70 | 16, 64, 256k and 1 Mega-Bit | Oxide Isolated (ALS) | 150 mA | 4 Banks of 16-Bit Data w/ 6-Bit ECC ea. | 63 ns/80 ns<br>50 ns/72 ns | | 15 ns/25 ns<br>15 ns/25 ns | | + 5V ± 10% | 0 to + 70<br>− 40 to + 85<br>− 55 to + 125 | 52D<br>68V |

*All AC values shown factor in worst-case loading (including all outputs switching simultaneously), operating temperature and $V_{CC}$ supply variables. All delays assume the use of National's on-board automatic delay line logic although external delay line control timing is allowed and supported.

# DP8420/21/22 MicroCMOS Programmable 256k, 1 or 4 Megabit DRAM Controller/Drivers

## General Description

National introduces another first in DRAM controllers, the DP8422. The first DRAM controller capable of directly addressing and driving an array of 4-megabit DRAMs up to 64-megabytes in size, the DP8422 can be easily interfaced to all major 8-, 16-, and 32-bit microprocessors without the need for previously required external support circuits.

The DP8422 is fabricated with National's 2-micron CMOS process for reduced power consumption. However, several speed enhancing features, such as programmable $t_{RAH}$ (Row Address Hold) and $t_{ASC}$ (Column Address Setup) times and the support of memory interleaving (which virtually eliminates RAS precharge time) aid in the improved performance level of this CMOS device. In addition, a built-in, high-precision, delay line that uses a high-speed Phase Lock Loop significantly enhances the DP8422's performance by tightening critical timing parameters.

The integration of programmable, on-chip, waitstate logic and the elimination of external support logic also aids in the improved performance level of the DP8422. By utilizing the most modern process techniques available, National has integrated all major features associated with the interface, control and drive of today's assortment of DRAMs.

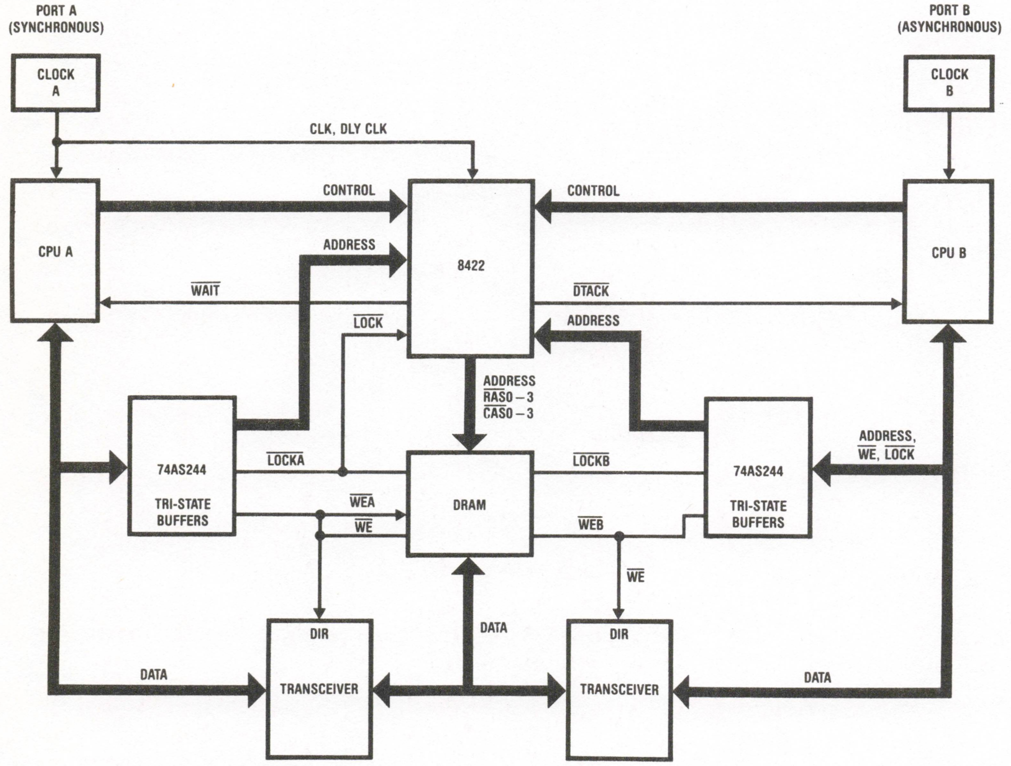
The DP8422 can be easily programmed to work with a variety of computer systems, regardless of DRAM access type. Adjustable control signal pulse widths allow the DP8422 to be used with the full spectrum of microprocessor/CPU operating frequencies, even beyond the 20 MHz boundary. In addition to the DP8422's programmable $t_{RAH}$ and $t_{ASC}$ times, it also allows programmable selection of RAS low time during refresh, the refresh time span, RAS precharge time, and the RAS/CAS configuration. The DP8422 also supports a variety of refresh operations, including staggered and burst refresh, which are automatic and transparent to the system.

The DP8422, along with the single-ported, 1-megabit DP8421 and 256-kbit DP8420 DRAM controller/drivers, is perfectly suited for a wide variety of DRAM-based applications where high-performance, no-wait-state, memory access is essential.

National has complemented the DP8420/21/22 programmable DRAM controller/drivers by packaging them in low cost 68-pin and 84-pin PCC packages.

Programmable Video RAM Controller/Drivers (DP8520/21/22) are also available as part of National's Advanced Graphics chip set.

**Dual Accessing with the DP8422**


PORT A (SYNCHRONOUS)
CLOCK A
PORT B (ASYNCHRONOUS)
CLOCK B
CLK, DLY CLK
CPU A
CONTROL
ADDRESS
WAIT
LOCK
8422
CONTROL
DTACK
ADDRESS
CPU B
ADDRESS RAS0 – 3 CAS0 – 3
74AS244 TRI-STATE BUFFERS
LOCKA
WEA
WE
DRAM
LOCKB
WEB
74AS244 TRI-STATE BUFFERS
ADDRESS, WE, LOCK
WE
DATA
DIR TRANSCEIVER
DATA
DIR TRANSCEIVER
DATA

# Application Specific ICs

For additional Application Specific IC products, see pages 231 and 419.

# ASIC Family

National Semiconductor's ASIC family utilizes a 2 micron (drawn, 1.6 micron effective) dual metal, silicon gate CMOS technology.

National's advanced CMOS technology is capable of achieving operating speed similar to Schottky-TTL but with the inherent lower power dissipation of standard CMOS technology.

All I/O and pad cells in the CMOS family have high noise immunity and are protected from static discharge.

All new LSI/VLSI chips designed at National Semiconductor utilize the same common CMOS process as National's ASICs. This facilitates encompassing these standard products as functional blocks in the standard cell library.

The SCX6200 Series Gate Array family currently ranges from 600–8700 gates, with a 13,000 gate array in design. The gates are arranged in cells, each cell having the equivalent of three 2-input NAND gates. All outputs have the ability to drive 10 LSTTL loads.

National Semiconductor supports a variety of design interfaces with Standard Cell and Gate Array technology. These range from producing integrated circuits from the user's schematic to accepting a database tape for mask generation. A large dedicated staff of integrated circuit design consultants are available at National's technology centers to help determine the most efficient and cost effective way to meet the user's semicustom integrated circuit requirements.

A well rounded package of easy-to-use design automation hardware and software is available to help the user quickly and easily implement and verify designs. These tools include workstation design kits, mainframe software for design integrity checks, logic simulation, timing verification, automatic cell placement and routing, IC layout design verification, and fault grading analysis to gauge testability.

A large selection of macros speeds up and simplifies the design process.

The system is tailored to allow the user to participate in the development of the circuit to the desired level.

## Product Features

- N-well CMOS technology with 2-micron (drawn, 1.6 effective channel length) geometries, silicon gates and dual-metal layered interconnects
- Ultra-high performance; less than 1 ns typical gate delays
- Minimal power dissipation
- All inputs fully protected from over-voltage, latch-up, and static discharge
- A full range of I/O cells for a variety of off-chip interfaces and drive capabilities:
  - —Bidirectional inputs/outputs
  - —Inputs compatible with TTL, CMOS, or Schmitt trigger levels
  - —Outputs compatible with CMOS and TTL and available in conventional, TRI-STATE®, or open drain configurations
- Common design tools for both gate arrays and standard cells
- National's standard cell library encompasses all functions available in National's Gate Array family, ensuring easy migration from gate arrays to more cost-efficient standard cells for high volume production
- Separate power supply traces for output drivers improve noise immunity
- A variety of packaging configurations up to 180 pins
- Alternately sourced

## Standard Cells Enhanced Product Features

- High current output drivers available with 4, 8, 12, 24 and 48 mA drive capabilities
- Multiple cell families available
  - —Large number of logic functions and I/O configurations
  - —RAMs, PLAs, UART, 2901
- Complete software support
  - —Schematic capture/netlist extraction for workstations
  - —Remote dial-in facilities available
  - —Easy-to-use menu-driven design system
  - —Netlist translators for selected formats
  - —Automated conversion of NSC gate array designs to standard cells
  - —Design integrity check program
  - —High accuracy timing delay calculator
  - —Fully automated cell placement and routing
  - —Pre- and post-layout logic/timing simulator
  - —Design and layout verification
  - —Automatic test conversion software
  - —Fully integrated database manager

## Gate Array Enhanced Product Features

- Available from 600 gates to 8700 gates, with higher densities in design
- Full design automation support
  - —Schematic capture
  - —Logic simulator with timing information
  - —Fault grading
- Multiple power rail pin connections
- Multiple packaging options in both ceramic and plastic; DIPs, PGAs, leaded and leadless chip carriers
- Military performance
- Extensive library of SSI and MSI functions
- 100 % auto-place-and-route at ≥ 95 % utilization
- Design automation system supported on mainframe and workstations
- TTL and CMOS compatible I/O buffers, including Schmitt triggers
  - —Output drive selectable: 1, 2, or 4 mA
  - —Low power oscillator macros

## Selectable Output Drive Capability

The enhanced I/O structure makes it possible to offer a variety of output drives for any given I/O location. Through implementation of I/O macro options, users can select output drives of 1, 2 or 4 mA for each output buffer.

## Parallel I/O Buffers for High Drives

Output drive current in excess of 4 mA can be achieved by paralleling I/O buffers while maintaining individual input functions. For example, to achieve 24 mA, six 4 mA I/O buffers need to be paralleled up; one pin is needed to implement the output (which can be bidirectional) while 5 pins can still be used as inputs.

## Absolute Maximum Ratings (Referenced to GND)

| Parameter | Symbol | Limits | Units |
|---|---|---|---|
| DC Supply Voltage | $V_{DD}$ | − 0.3 to + 7 | V |
| Input Voltage | $V_I$ | − 0.3 to $V_{DD}$ + 0.3 | V |
| DC Input Current | $I_I$ | ± 10 | mA |
| Storage Temperature Range (Ceramic) | $T_{STG}$ | − 65 to + 150 | °C |

## Recommended Operating Conditions

| Parameter | Symbol | Limits | Units |
|---|---|---|---|
| DC Supply Voltage | $V_{DD}$ | 3 to 6 | V |
| Operating Ambient Temperature Range Military | $T_A$ | − 55 to + 125 | °C |

## DC Characteristics Specified at $V_{DD}$ = 5V ± 10 %

| Symbol | Parameter | Conditions | $V_{DD}$ | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| $V_{IL(max)}$ | Low Level Input Voltage | $\|IO\| \leq 20\ \mu A$ | | | | | |
| | CMOS Level | | 4.5V | | | 0.3 $V_{DD}$ | V |
| | TTL Level (Note 1) | | 4.5V | | | 0.8 | V |
| $V_{IH(min)}$ | High Level Input Voltage | $\|IO\| \leq 20\mu A$ | | | | | |
| | CMOS Level | | 5.5V | 0.7 $V_{DD}$ | | | V |
| | TTL Level (Mil/Comm) (Note 1) | | 5.5V | 2.25 | | | V |
| $V_{T+(max)}$ | Positive Going Threshold Voltage—Schmitt Trigger (Note 1) | | | | | 4.0 | V |
| $V_{T-(min)}$ | Negative Going Threshold Voltage—Schmitt Trigger (Note 1) | | | 0.7 | | | V |
| $V_{H(typ)}$ | Hysteresis Voltage—Schmitt Trigger (Note 1) | | | 1.0 | 1.5 | | V |
| $I_{IL(max)}$ | Low Level Input Current with Pull Up Resistor | $V_{IN} = V_{SS}$ | 5.5V<br>5.5V | | <br>− 40 | − 10<br>− 200 | μA<br>μA |
| $I_{IH(max)}$ | High Level Input Current with Pull Down Resistor | $V_{IN}$ = 5.5V | 5.5V<br>5.5V | | <br>40 | 10<br>200 | μA<br>μA |
| $V_{OL(max)}$ | Low Level Output Voltage | $V_{IN} = V_{IL}$ or $V_{IH}$ | | | | | |
| | | $I_{OL}$ = 20 μA | 4.5V | | | 0.1 | V |
| | | $I_{OL}$ = 1 mA | 4.5V | | 0.2 | 0.4 | V |
| | | $I_{OL}$ = 2 mA | 4.5V | | 0.2 | 0.4 | V |
| | | $I_{OL}$ = 4 mA | 4.5V | | 0.2 | 0.4 | V |
| $V_{OH(min)}$ | High Level Output Voltage | $V_{IN} = V_{IL}$ or $V_{IH}$ | | | | | |
| | | $I_{OH}$ = − 20 μA | 4.5V | $V_{DD}$ − 0.1 | | | V |
| | | $I_{OH}$ = − 1 mA | 4.5V | 3.7 | | | V |
| | | $I_{OH}$ = − 2 mA | 4.5V | 3.7 | | | V |
| | | $I_{OH}$ = − 4 mA | 4.5V | 3.7 | | | V |
| $I_{OZL(max)}$ | Low Level TRI-STATE Output Current (Notes 2,3) | $V_O = V_{SS}$<br>$V_{IN(EN)} = V_{IL}$ or $V_{IH}$ | 5.5V | | | − 10 | μA |
| $I_{OZH(max)}$ | High Level TRI-STATE Output Current (Notes 2,3) | $V_O$ = 5.5V<br>$V_{IN(EN)} = V_{IL}$ or $V_{IH}$ | 5.5V | | | 10 | μA |
| $I_{DD}$ | Quiescent Supply Current | $V_{IN} = V_{SS}$ or $V_{DD}$ | | | User Design Dependent | | |
| $C_{IN}$ | Input Capacitance (Note 4) | | | | 5 | 10 | pF |
| $C_{OUT}$ | Output Capacitance (Note 4) | | | | 7 | 20 | pF |

**Note 1:** This parameter cannot be guaranteed unless a combinatorial logic path is defined.

**Note 2:** $I_{OZ}$ specs are for output buffers without pull up or down resistors.

**Note 3:** Spec. limits for I/Os with both TRI-STATE outputs and pull up or down resistors will be the sum of the individual leakages.

**Note 4:** $C_{IN}$ and $C_{OUT}$ specs are guaranteed by design.

## Propagation Delays of Selected Macros (in ns) Note 1

| | | Best-Case | | Worst-Case | | |
|---|---|---|---|---|---|---|
| Symbol | Function | $t_{PLH}$ | $t_{PHL}$ | $t_{PLH}$ | $t_{PHL}$ | $C_{LOAD}$ (pF) |
| C001 | 2-NAND | 0.095 | 0.19 | 0.75 | 0.95 | 0 |
| | | 0.39 | 0.67 | 2.40 | 4.05 | 1 |
| C002 | 3-NAND | 0.09 | 0.27 | 0.95 | 1.65 | 0 |
| | | 0.37 | 0.92 | 2.65 | 5.75 | 1 |
| C004 | 2-NOR | 0.16 | 0.15 | 1.1 | 0.95 | 0 |
| | | 0.62 | 0.51 | 4.15 | 2.85 | 1 |
| C005 | 3-NOR | 0.23 | 0.16 | 1.65 | 1.13 | 0 |
| | | 0.85 | 0.52 | 6.1 | 3.05 | 1 |
| C007 | Clock Buffer | 0.07 | 0.13 | 0.45 | 0.55 | 0 |
| | | 0.24 | 0.33 | 1.45 | 1.65 | 1 |
| C008 | Inverter | 0.095 | 0.16 | 0.6 | 0.75 | 0 |
| | | 0.36 | 0.52 | 2.35 | 2.6 | 1 |
| C011 | 2-XOR | 0.11 | 0.16 | 2.6 | 2.5 | 0 |
| | | 0.54 | 0.53 | 5.8 | 5.65 | 1 |
| C023 | D Flip-Flop | | | | | |
| | CLK to Q | 0.71 | 0.59 | 5.12 | 4.38 | 0 |
| | | 1.02 | 0.94 | 7.0 | 6.25 | 1 |
| | CLK to $Q_B$ | 0.35 | 0.54 | 2.38 | 3.3 | 0 |
| | | 0.64 | 0.98 | 5.37 | 6.62 | 1 |
| C009 | TRI-STATE Inverter | 0.18 | 0.18 | 1.2 | 1.35 | 0 |
| | | 0.60 | 0.70 | 4.25 | 4.15 | 1 |
| C010 | TRI-STATE Buffer | 0.30 | 0.27 | 1.9 | 1.8 | 0 |
| | | 0.53 | 0.53 | 3.4 | 3.4 | 1 |
| $I_4$ | CMOS Inverting Input Buffer | 0.23 | 0.19 | 0.85 | 0.70 | 0 |
| | | 0.45 | 0.39 | 2.30 | 1.80 | 1 |
| $I_1$ | TTL Input Buffer | 0.33 | 0.39 | 2.0 | 2.45 | 0 |
| | | 0.60 | 0.78 | 3.70 | 4.80 | 1 |
| $I_6$ | CMOS Short Circuit Input | 0.04 | 0.04 | 0.07 | 0.07 | 0 |
| | | 0.15 | 0.15 | 0.50 | 0.50 | 1 |
| $IO_1$ (Note 2) | TTL Input | 0.33 | 0.39 | 2.0 | 2.45 | 0 |
| | | 0.60 | 0.78 | 3.7 | 4.8 | 1 |
| | Output | 0.62 | 0.78 | 4.4 | 5.75 | 15 |
| | | 1.15 | 1.55 | 7.0 | 9.75 | 50 |
| $IO_2$ (Note 2) | CMOS Inverting Input Buffer | 0.23 | 0.19 | 0.85 | 0.70 | 0 |
| | | 0.45 | 0.39 | 2.30 | 1.80 | 1 |
| | Output | 0.62 | 0.78 | 4.40 | 5.75 | 15 |
| | | 1.15 | 1.55 | 7.0 | 9.75 | 50 |
| $IO_3$ (Note 2) | CMOS Short Circuit Input | 0.04 | 0.04 | 0.07 | 0.07 | 0 |
| | | 0.15 | 0.15 | 0.50 | 0.50 | 1 |
| | Output | 0.62 | 0.78 | 4.40 | 5.75 | 15 |
| | | 1.15 | 1.55 | 7.0 | 9.75 | 50 |
| $IO_4$ (Note 2) | Output | 0.65 | 0.63 | 4.75 | 4.5 | 15 |
| | | 1.17 | 1.45 | 8.25 | 8.25 | 50 |

Note 1: These are sample propagation delay specifications for a sample application. Actual specifications are determined by simulation of the customer's circuit.

Note 2: Input pulse = 1 MHz; 50% duty cycle; $t_r = t_f = 6$ ns; CMOS = 0V to 5V; TTL = 0V to 3V.
$t_r = t_f = 2.5$ ns for 2-micron
Voltage Derate = 1.5%/100 mV from 4.5V to 5V
Temperature Derate = 0.14%/°C from 100°C to −55°C
0.4%/°C from 100°C to 140°C

| Best-Case | Worst-Case |
|---|---|
| Temperature = −40°C | Temperature = 100°C |
| Supply Voltage = 5.5V | Supply Voltage = 4.5V |
| Extreme Process | Extreme Process |
| (Fastest) | (Slowest) |

## Gate Array/Standard Cell Library

| Name | GA Cells | SCL Grids | Description |
|---|---|---|---|
| **GATES** | | | |
| C001 | 1/3 | 3 | 2-Input NAND Gate |
| C002 | 1/2 | 4 | 3-Input NAND Gate |
| C003 | 1/2 | 5 | 2-Input NAND Gate with Complement |
| C004 | 1/3 | 3 | 2-Input NOR Gate |
| C005 | 1/2 | 4 | 3-Input NOR Gate |
| C006 | 1/2 | 5 | 2-Input NOR Gate with Complement |
| C011 | 1 | 8 | 2-Input Exclusive OR Gate |
| C014 | 1 | 7 | 4-Input OR-NAND Gate with Complement |
| C015 | 1 | 8 | 4-Input AND-OR Gate with Complement |
| C017 | 2/3 | 5 | 4-Input NAND Gate |
| C018 | 2 | 6 | 5-Input NAND Gate (2X Drive) |
| C019 | 2/3 | 6 | 3-Input NAND Gate with Complement |
| C020 | 2/3 | 5 | 4-Input NOR Gate |
| C021 | 2 | 6 | 5-Input NOR Gate (2X Drive) |
| C022 | 2/3 | 6 | 3-Input NOR Gate with Complement |
| C046 | 3 | 18 | 4-Input Exclusive-OR Gate |
| C047 | 2 | 16 | 3-Input Exclusive-OR Gate |
| C048 | 1 | 8 | 2-Input Exclusive-NOR Gate |
| C053 | 1 | 8 | 2-Input Exclusive-NOR Gate (2X Drive) |
| C057 | 2 | 8 | 5-Input NAND Gate with Complement |
| C058 | 2 | 8 | 5-Input NOR Gate with Complement |
| C800 | 2 | 16 | 3-Input Exclusive-NOR Gate (2X Drive) |
| C801 | 3/4 | | 4-Input Exclusive-NOR Gate |
| C830 | 2 | 9 | 8-Input NAND Gate with Complement |
| C878 | 2 | 9 | 8-Input NOR Gate with Complement |
| **BUFFERS** | | | |
| C007 | 1/3 | 3 | Inverter (2X Drive) |
| C008 | 1/4 | 2 | Inverter |
| C009 | 1/2 | 4 | TRI-STATE Inverter |
| C010 | 1 | 8 | TRI-STATE Buffer |
| C025 | 1 | 7 | Schmitt Trigger (2X Drive) |
| C043 | 1 | 4 | Inverter (4X Drive) |
| C044 | 1/2 | 4 | Inverter (3X Drive) |
| C045 | 1 | 6 | Inverter (1X Drive) with Complement (3X Drive) |
| C049 | 1 | 6 | Inverter (2X Drive) with Complement (2X Drive) |
| C061 | 1 | 6 | Inverter (3X Drive) with Complement (1X Drive) |
| C808 | 1 | | Quad Pull-Down Buffer with Common Enable-Bar |
| C811 | 2 | 29 | Quad Pull-Down Buffer with Decoder for 6 Enable-Bars |
| C812 | 2 | | Quad Pull-Up Buffer with Decoder for 6 Enables |
| C832 | 1 | 6 | Quad Pull-Up Buffer with Common Enable |
| **LATCHES** | | | |
| C012 | 1 | 8 | NAND Latch and 2-Input NAND Gate |
| C013 | 1 | 8 | NOR Latch and 2-Input NOR Gate |
| C026 | 2 | 13 | 1-Bit D-Latch with Reset-Bar and Enable-Bar |
| C027 | 2/3 | 5 | NAND Latch with Reset-Bar and Set-Bar |
| C031 | 2/3 | 5 | NOR Latch with Reset and Set |
| C062 | 2 | 15 | D-Latch with Reset-Bar and Set |
| C072 | 1 | | D-Latch with Enable |
| C073 | 1 | | D-Latch with Enable-Bar |

| Name | GA Cells | SCL Grids | Description |
|---|---|---|---|
| **MULTIPLEXERS AND DEMULTIPLEXERS** | | | |
| C016 | 1 | 9 | 2 to 1 Multiplexer |
| C028 | 3 | 21 | 4 to 1 TRI-STATE Multiplexer |
| C029 | 3 | 20 | 4 to 1 Multiplexer |
| C033 | 4 | 19 | 2 to 4 Decoder |
| C056 | 1 | 9 | 2 to 1 Multiplexer |
| C138 | 6 | | 3 to 8 Decoder |
| C151 | 6 | | 8 to 1 Multiplexer with Strobe |
| C157 | 4 | 37 | Quad 2 to 1 Multiplexer with Select-Bar and Enable-Bar |
| C257 | 4 | | Quad 2 to 1 Multiplexer with Select-Bar and Enable-Bar |
| **REGISTERS AND COUNTERS** | | | |
| C038 | 5 | 35 | Presettable Up/Down Counter |
| C039 | 5 | 38 | 2-Bit Register with Serial-In and Serial/Parallel Out |
| C042 | 6 | 41 | 2-Bit Shift Register with Serial/Parallel-In and Serial/Parallel-Out |
| C194 | 5 | | 1-Bit Universal Shift Register |
| C871 | 4 | | Binary Counter Control Logic |
| **MEMORY BLOCKS FOR GATE ARRAYS** | | | |
| C065 | 30 | | 8 × 2 Static RAM |
| C066 | 42 | | 8 × 4 Static RAM |
| C067 | 66 | | 8 × 8 Static RAM |
| C068 | 90 | | 8 × 12 Static RAM |
| **ARITHMETIC FUNCTIONS** | | | |
| C030 | 3 | 18 | 4-Bit Parity Checker |
| C032 | 3 | 17 | 1-Bit Full Adder |
| C040 | 6 | 42 | 7 Function 1-Bit ALU |
| C041 | 6 | 48 | 2-Bit Magnitude Comparator |
| **FLIP-FLOPS** | | | |
| C023 | 2 | 16 | D Flip-Flop |
| C024 | 3 | 19 | D Flip-Flop with Set-Bar and Reset-Bar |
| C034 | 4 | | D Flip-Flop with Reset and Parallel Data In with Load-Bar |
| C035 | 4 | 29 | Multiplexed D Flip-Flop with Reset |
| D035 | | | Dedicated Multiplexed D Flip-Flop with Reset |
| C036 | 4 | 22 | T Flip-Flop with Toggle Enable and Reset-Bar |
| C037 | 5 | 25 | J-K Flip-Flop with Reset and Set |
| C059 | 2 | | D Flip-Flop (2X Drive) |
| C060 | 3 | | D Flip-Flop with Reset-Bar and Set-Bar |
| C063 | 4 | | Multiplexed D Flip-Flop |
| C064 | 2 | 18 | D Flip-Flop with Reset |
| C070 | 4 | 24 | Multiplexed D Flip-Flop with Reset |
| C071 | 4 | 25 | J-K Flip-Flop with Reset and Set |
| C861 | 4 | | T Flip-Flop with Reset-Bar and Parallel Enable |

## Input Buffers

| | TTL Inputs | | | CMOS Inputs | | | | | | Schmitt Trigger Inputs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Non-Inverting | | | Inverting | | | Non-Inverting | | | Non-Inverting | | |
| | 1X | 7X | 15X | 1X | 7X | 15X | 1X | 7X | 15X | 1X | 7X | 15X |
| No Resistor | I2*<br>I07*<br>IB0N | IB2N | IB4N | I4*<br>I09*<br>IE0N | IE2N | IE4N | IF0N | IF2N | IF4N | IK0N | IK2N | IK4N |
| With Pull-Up | I1*<br>I06*<br>IB0U | IB2U | IB4U | I3*<br>I08*<br>IE0U | IE2U | IE4U | IF0U | IF2U | IF4U | IK0U | IK2U | IK4U |
| With Pull-Down | IB0D | IB2D | IB4D | IE0D | IE2D | IE4D | IF0D | IF2D | IF4D | IK0D | IK2D | IK4D |

*Available for 6212, 6225 and standard cells. All other input buffers available for 6206, 6218, 6232, 6244, 6287 and standard cells.

## Bidirectionals

| | TTL I/Os | | | CMOS I/Os | | | | | | Schmitt Trigger I/Os | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Non-Inverting | | | Inverting | | | Non-Inverting | | | Non-Inverting | | |
| | 1 mA | 2 mA | 4 mA | 1 mA | 2 mA | 4 mA | 1 mA | 2 mA | 4 mA | 1 mA | 2 mA | 4 mA |
| No Resistor | BB0B1N | BB0B2N | BB0B4N | BE0B1N | BE0B2N | BE0B4N<br>I02* | BF0B1N | BF0B2N | BF0B4N | BK0B1N | BK0B2N | BK0B4N |
| With Pull-Up | BB0B1U | BB0B2U | BB0B4U<br>I012* | BE0B1U | BE0B2U | BE0B4U<br>I013* | BF0B1U | BF0B2U | BF0B4U | BK0B1U | BK0B2U | BK0B4U |
| With Pull-Down | BB0B1D | BB0B2D | BB0B4D | BE0B1D | BE0B2D | BE0B4D | BF0B1D | BF0B2D | BF0B4D | BK0B1D | BK0B2D | BK0B4D |

*Available for 6212, 6225 and standard cells. All other bidirectionals available for 6206, 6218, 6232, 6244, 6287 and standard cells.

## TTL/CMOS Output Buffers

| Inverting | | | Non-Inverting | | |
|---|---|---|---|---|---|
| 1 mA | 2 mA | 4 mA | 1 mA | 2 mA | 4 mA |
| YC1 | YC2 | YC4 | YD1 | YD2 | YD4<br>I04* |

*Available for 6212, 6225 and standard cells. All other output buffers available for 6206, 6218, 6232, 6244, 6287 and standard cells.

## Oscillators (with non-inverting Schmitt trigger inputs)

| | Output DriveYA | No Resistor | | With Pull-Up | | With Pull-Down | |
|---|---|---|---|---|---|---|---|
| | Output Drive BP1 | 2X | 15X | 2X | 15X | 2X | 15X |
| Standard | 1 mA | | 0K4C1N | | 0K4C1U | | 0K4C1D |
| | 2 mA | | 0K4C2N | | 0K4C2U | | 0K4C2D |
| | 4 mA | I043* | 0K4C4N | | 0K4C4U | I045* | 0K4C4D |
| Gated | 1 mA | | 0K4J1N | | 0K4J1U | | 0K4J1D |
| Low Power | 1 mA | 0K4CL0 | | | | | |

*Available for 6212, 6225 and standard cells. All other oscillators available for 6206, 6218, 6232, 6244, 6287 and standard cells.

## Dedicated Multiplexed D Flip-Flops

A number of dedicated multiplexed D flip-flops is incorporated into the internal array core. These flip-flops have been designed to achieve significant system speed improvement over a logically equivalent macrofunction while minimizing silicon space. They are ideal for scan path design techniques as well as for fast registers and counters.

## Standard Cell Hardware

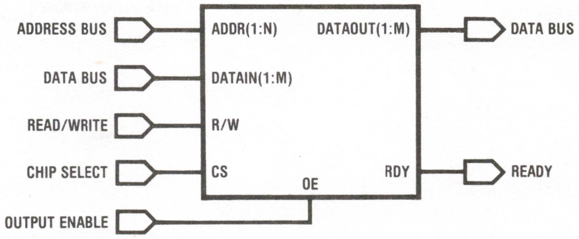
### RAMs

- Single Port RAM Blocks:
  64 × 4  32 × 8  16 × 16
  256 × 4  64 × 8  16 × 32
  128 × 8
  256 × 8
  These RAMs are stackable to create larger configurations
- Performance:
  25 ns data access time
  50 ns cycle time
- Other Features:
  —Fully static operation
  —Synchronous
- Dual Port RAM Macros:
  4 × 4  4 × 8  4 × 9  4 × 16  4 × 18
  8 × 4  8 × 8  8 × 9  8 × 16  8 × 18
  16 × 4  16 × 8  16 × 9  16 × 16  16 × 18
  32 × 4  32 × 8  32 × 9  32 × 16  32 × 18
  These RAMs are stackable to create larger configurations.
- Performance:
  25 ns data access time
  40 ns cycle time
- Other Features:
  —Fully static operation
  —Built in contention logic

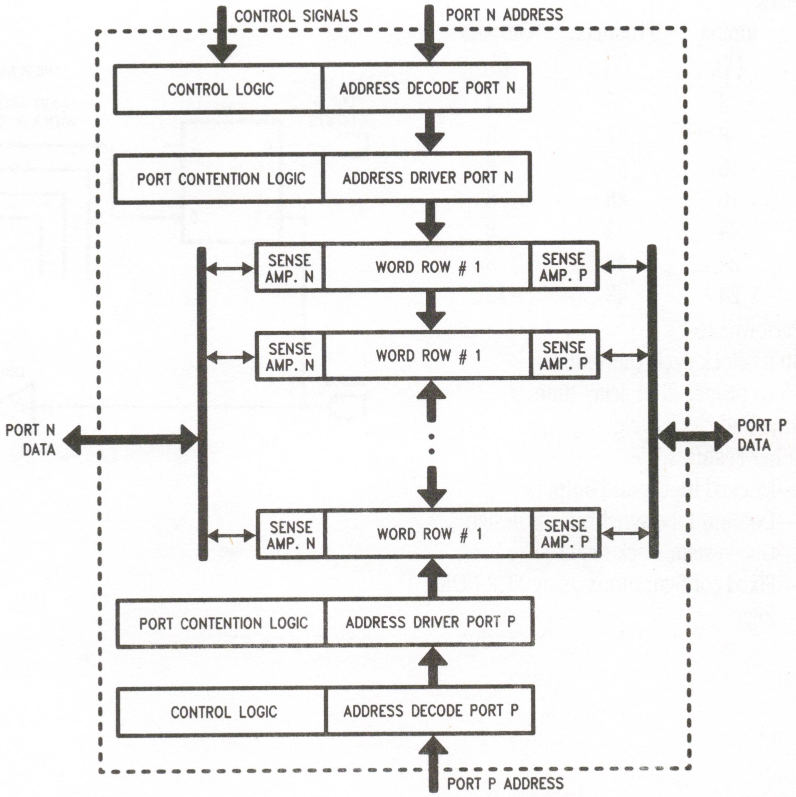
| Array Name | Equivalent 2-Input Gates (Note 1) | Input Cells | I/O Cells | Signal Pins | Test Pins | $V_{DD}$ Pins | $V_{SS}$ Pins |
|---|---|---|---|---|---|---|---|
| SCX6206 | 600 | 8 | 40 | 48 | 1 | 4 | 4 |
| SCX6212 | 1260 | 17 | 42 | 59 | 1 | 4 | 4 |
| SCX6218 | 1806 | 3 | 70 | 73 | 1 | 8 | 8 |
| SCX6225 | 2430 | 12 | 76 | 88 | 1 | 6 | 6 |
| SCX6232 | 3162 | 3 | 101 | 104 | 1 | 8 | 8 |
| SCX6244 | 4380 | 3 | 110 | 113 | 1 | 8 | 8 |
| SCX6287 | 8700 | 3 | 152 | 155 | 1 | 8 | 8 |

Note 1: Input and I/O cells are not considered part of the internal cell count.

**Block Diagram (Single Port RAM)**


ADDRESS BUS
DATA BUS
READ/WRITE
CHIP SELECT
OUTPUT ENABLE
ADDR(1:N)
DATAOUT(1:M)
DATAIN(1:M)
R/W
CS
OE
RDY
DATA BUS
READY

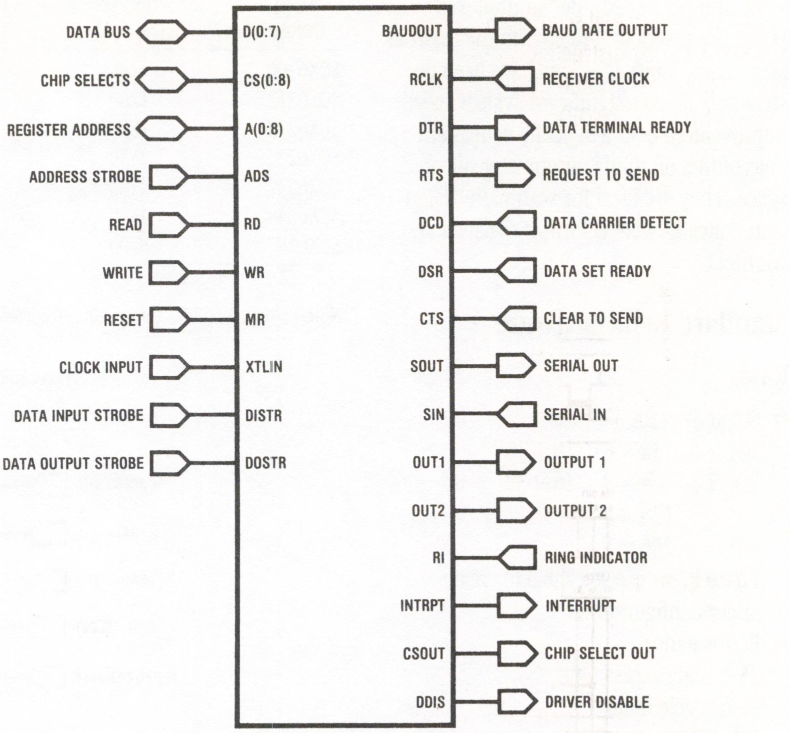
**Block Diagram (Dual Port RAM)**


CONTROL SIGNALS
PORT N ADDRESS
CONTROL LOGIC
ADDRESS DECODE PORT N
PORT CONTENTION LOGIC
ADDRESS DRIVER PORT N
SENSE AMP. N
WORD ROW # 1
SENSE AMP. P
SENSE AMP. N
WORD ROW # 1
SENSE AMP. P
PORT N DATA
PORT P DATA
SENSE AMP. N
WORD ROW # 1
SENSE AMP. P
PORT CONTENTION LOGIC
ADDRESS DRIVER PORT P
CONTROL LOGIC
ADDRESS DECODE PORT P
PORT P ADDRESS

## UART (INS82C50B/82C50A/16C450)

- Features:
  - —Parallel communication with 8-bit data bus
  - —Standard asynchronous serial communication (RS-232)
  - —Fully programmable serial interface (PARITY, STOP, BITS, BAUD)
  - —Baud rate generator (divide by 1 to $2^{16} - 1$, 10 MHz clock)
  - —Independent receiver clock input
  - —MODEM control functions (CTS, TTS, DSR, DTR, RI, Carrier Detect)
  - —Complete status reporting capabilities
  - —Line break generation and detection
  - —Internal diagnostic capabilities
  - —Prioritized, independently controlled interrupts (4 levels)

**Block Diagram (UART)**


DATA BUS
CHIP SELECTS
REGISTER ADDRESS
ADDRESS STROBE
READ
WRITE
RESET
CLOCK INPUT
DATA INPUT STROBE
DATA OUTPUT STROBE
D(0:7)
CS(0:8)
A(0:8)
ADS
RD
WR
MR
XTLIN
DISTR
DOSTR
BAUDOUT
RCLK
DTR
RTS
DCD
DSR
CTS
SOUT
SIN
OUT1
OUT2
RI
INTRPT
CSOUT
DDIS
BAUD RATE OUTPUT
RECEIVER CLOCK
DATA TERMINAL READY
REQUEST TO SEND
DATA CARRIER DETECT
DATA SET READY
CLEAR TO SEND
SERIAL OUT
SERIAL IN
OUTPUT 1
OUTPUT 2
RING INDICATOR
INTERRUPT
CHIP SELECT OUT
DRIVER DISABLE

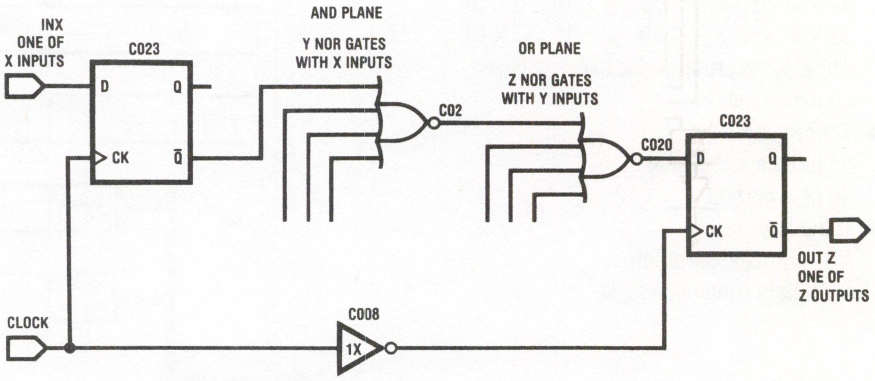
## PLA

- Sizes:

| Inputs (X) | Products (Y) | Outputs (Z) |
|---|---|---|
| 8 | 16 | 4 |
| 8 | 32 | 8 |
| 16 | 32 | 8 |
| 16 | 48 | 8 |
| 24 | 32 | 8 |
| 24 | 48 | 8 |
| 24 | 48 | 12 |

- Performance:
  30 ns clock cycle (minimum)
  15 ns propagation delay time (one-half clock cycle)
- Other Features:
  - —Latched inputs and outputs
  - —Domino-type synchronous design
  - —One system clock required
  - —Fixed configurations using NOR-NOR logic

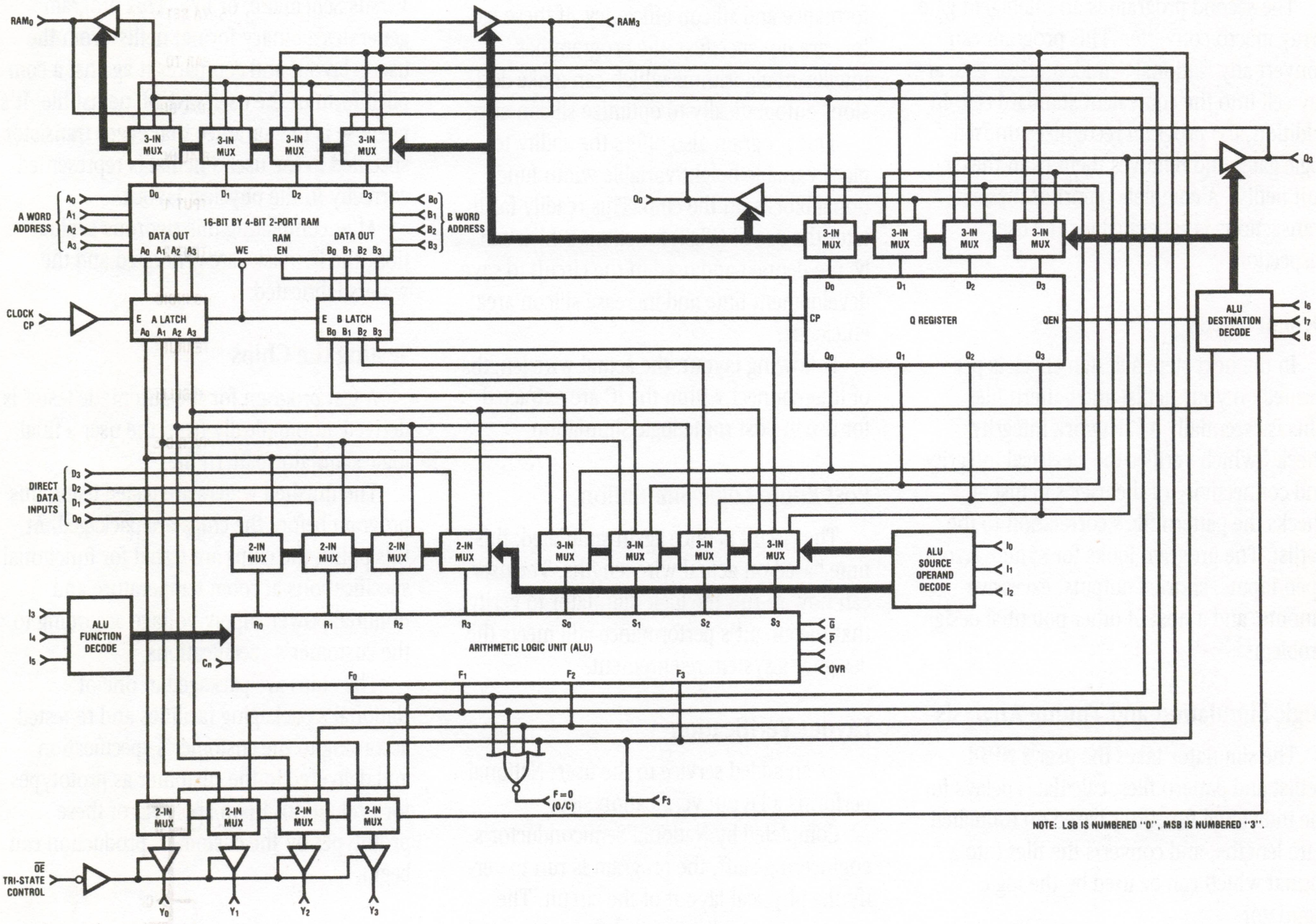
**Block Diagram (PLA)**


INX
ONE OF
X INPUTS
C023
D
Q
CK
Q̄
AND PLANE
Y NOR GATES
WITH X INPUTS
C02
OR PLANE
Z NOR GATES
WITH Y INPUTS
C020
C023
D
Q
CK
Q̄
OUT Z
ONE OF
Z OUTPUTS
CLOCK
C008
1X

## 4-Bit Microprocessor (IDM2901)

- Features:
  - —Expandable from 4-bits to 32-bits
  - —32 × 4 internal scratchpad
  - —9-bit microinstruction words
  - —Multifunction ALU (ADD, SUB, OR, AND, XOR, XNOR)
  - —Left/right shift independent of ALU
  - —Four status flags (CARRY, OVERFLOW, ZERO, SIGN)
  - —Flexible data-source selection

### Block Diagram (4-Bit Microprocessor)


RAM0
RAM3
3-IN MUX
D0 D1 D2 D3
A WORD ADDRESS
A0 A1 A2 A3
16-BIT BY 4-BIT 2-PORT RAM
DATA OUT
RAM EN
WE
B0 B1 B2 B3
B WORD ADDRESS
CLOCK CP
E A LATCH
E B LATCH
Q0
Q3
Q REGISTER
CP
QEN
ALU DESTINATION DECODE
I6 I7 I8
DIRECT DATA INPUTS
2-IN MUX
ALU SOURCE OPERAND DECODE
I0 I1 I2
I3 I4 I5
ALU FUNCTION DECODE
Cn
R0 R1 R2 R3
S0 S1 S2 S3
ARITHMETIC LOGIC UNIT (ALU)
F0 F1 F2 F3
G̅ P̅ OVR
F=0 (O/C)
F3
OE
TRI-STATE CONTROL
Y0 Y1 Y2 Y3
NOTE: LSB IS NUMBERED "0", MSB IS NUMBERED "3".

## The Design Automation System

### Netlist Translators for Standard Cell Designs

Once a netlist and pattern file have been transferred to mainframe, a netlist translator will convert the design description into the National Hardware Description Language (NHDL). Two translation programs are available. One program simply converts the pinlist format into NHDL.

The second program is an intelligent gate array macro converter. This program can convert any National Semiconductor gate array cell into the equivalent standard cell. In addition, the program recognizes unused logic gates and removes them from the circuit netlist. A complete report of these transactions is generated for the user's inspection.

### Design Check

In the next step, a design check is performed on your netlist and pattern files. This is essentially a ''network integrity check'' which verifies the electrical integrity and connectivity of the user's netlist and checks the pattern file's correlation to the netlist. The program looks for syntax errors, open inputs, shorted outputs, excessive fanouts, and a host of other potential design problems.

### Logic Simulation and Timing Analysis

The simulator takes the user's NHDL netlist and pattern files, calculates delays for the individual functions based on estimated wire lengths, and converts the files into a format which can be used by the logic simulator.

The user then runs the simulator to verify the logical function of the netlist and pattern files. A simulation post processor is also available to simplify simulation output analysis. (Its function is very similar to a benchtop logic analyzer.)

### Automatic Place and Route

The complete layout of your IC is accomplished using the latest development in automated place and route software.

The program is controlled by an AUXILIARY file, which allows the user to specify pin-out, bonding information, forced cell placement, and signal priority weighting factors. These features and others allow the user to specify layout parameters which can, in some cases, drastically affect circuit performance and silicon efficiency. If these factors are not specified, the program has intelligent algorithms which can make decisions automatically to optimize silicon area.

This program also offers the ability to place variable height/variable width functional blocks on the chip. This readily facilitates the use of (VLSI) functions which can be pre-defined and used in the circuit to save development time and increase silicon area efficiency.

Following layout, the actual wire lengths of interconnect within the IC are extracted for use in post route logic simulation.

### Post Route Logic Simulation

The circuit is once again simulated, this time based on actual wire lengths. The user can now re-run the logic simulator to verify that the circuit's performance still meets the designer's system requirement.

### Layout Verification

As an added service to the user, National performs a layout verification step.

Completed by National Semiconductor's engineering staff, the program is run to verify the physical layout of the circuit. The program is actually a series of program modules which checks particular aspects of the design.

The first program module is the Layout Design Rule Check, which is also referred to as DRC. This step compares the physical geometries of the layout against process design rules. The geometries are checked for spacing, width, overlap and a variety of other parameters which can affect circuit operation.

The second module is the Electrical Rule Check, or ERC. This program analyzes the physical layout for gross electrical errors such as shorted power supply lines and disconnected transistors.

The final program module run is Layout Versus Schematic, or LVS. This program generates a binary format netlist from the user's layout and compares it against a compiled form of the user's NHDL netlist file. It's purpose is to guarantee that every transistor specified in the user's netlist is represented correctly in the physical layout.

After completing this rigorous evaluation, the IC masks are generated and the wafers fabricated.

### Testing the Chips

A test program for the automatic tester is derived automatically from the user's final logic simulator pattern file.

The finished wafers are tested using this program before the chips are packaged. At this point, the chips are tested for functional specifications at room temperature and nominal power supply voltage according to the customer's specifications.

The chips are packaged in one of National's packaging facilities and re-tested according to the customer's specification and delivered to the customer as prototypes for evaluation. Upon approval of these prototypes by the customer, production can begin.

## Database Management System

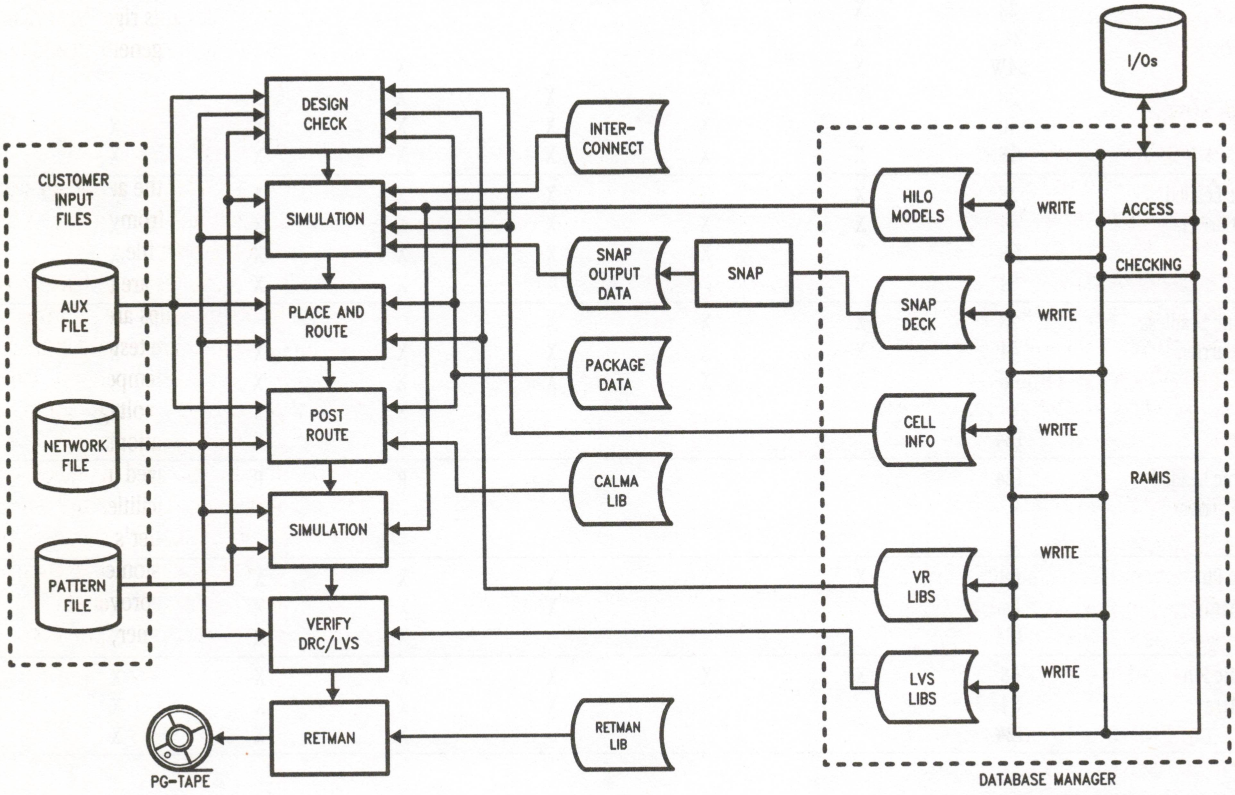
National Semiconductor's ASIC data is managed using a centralized database system revolving around a single database file and a commercial database program. In-house software has been written around this package tailoring input and output to suit the requirements of each software package used during the Design Automation cycle. The system provides full archiving of all cell revisions, enabling fast and accurate updates to cells, and recreation of any particular data environment on demand.

Input to the system is designed to take in all data for a single cell with one input file. The input file encompasses all information necessary to the running of any phase of the Design Automation cycle (i.e., design check, timing analysis, place and route, etc.). Revision control is handled automatically with each addition or update.

All input files needed by any of the applications in the Automated Design System are automatically regenerated after each update of the central database. In this way, customers are guaranteed that any additions to the standard cell family will be made available with minimal turnaround time.

The centralized database scheme allows for easy incorporation of new Design Automation tools as they are developed. New output formats for existing data are easily defined, and additional data needs may be incorporated into the database scheme without disturbing existing data.

**Database Management System**

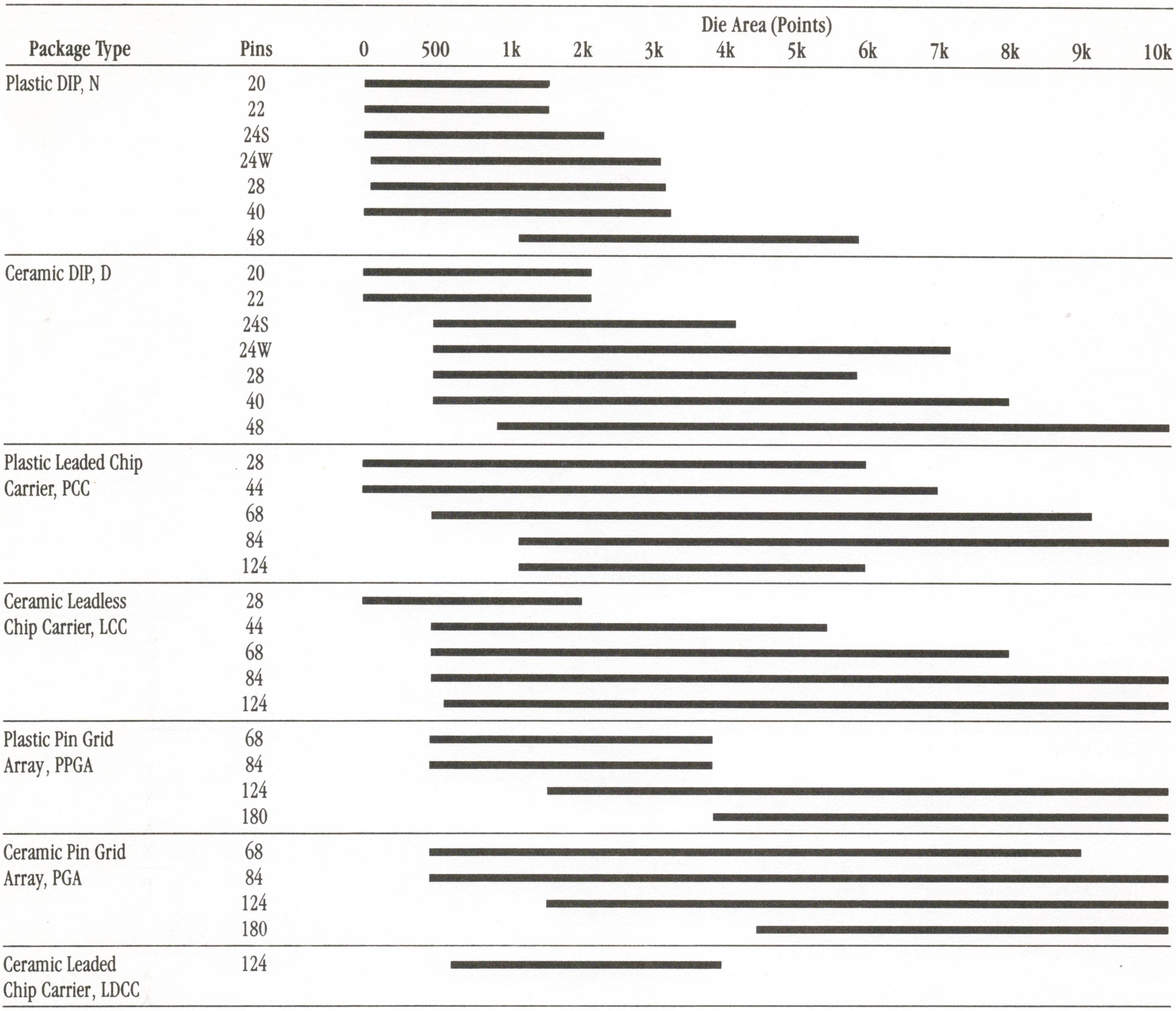

I/Os
CUSTOMER INPUT FILES
AUX FILE
NETWORK FILE
PATTERN FILE
DESIGN CHECK
SIMULATION
PLACE AND ROUTE
POST ROUTE
SIMULATION
VERIFY DRC/LVS
RETMAN
PG-TAPE
INTER-CONNECT
SNAP OUTPUT DATA
SNAP
PACKAGE DATA
CALMA LIB
RETMAN LIB
HILO MODELS
SNAP DECK
CELL INFO
VR LIBS
LVS LIBS
WRITE
WRITE
WRITE
WRITE
WRITE
ACCESS
CHECKING
RAMIS
DATABASE MANAGER

## Packaging Information Gate Array

| Package Type | Pins | 6206 | 6212 | 6218 | 6225 | 6232 | 6244 | 6287 |
|---|---|---|---|---|---|---|---|---|
| Plastic DIP, N | 8 | X | | | | | | |
| | 14 | X | | | | | | |
| | 16 | X | | | | | | |
| | 18 | X | | | | | | |
| | 20 | X | | | | | | |
| | 22 | X | X | | | | | |
| | 24S | X | | | | | | |
| | 24W | X | X | X | X | X | X | |
| | 28 | X | X | X | X | X | X | |
| | 40 | X | X | X | X | X | X | |
| | 48 | X | X | X | X | X | X | |
| Ceramic DIP, D (Side Braze) | 8 | X | | | | | | |
| | 14 | X | | | | | | |
| | 16 | X | | | | | | |
| | 18 | X | | | | | | |
| | 20 | X | | | | | | |
| | 22 | X | X | | | | | |
| | 24S | X | | | | | | |
| | 24W | X | X | X | X | | | |
| | 28 | X | X | X | X | | | |
| | 40 | X | X | X | X | X | X | |
| | 48 | X | X | X | X | X | X | |
| Plastic Leaded Chip Carrier, PCC | 28 | X | X | X | X | X | X | |
| | 44 | X | X | X | X | X | X | |
| | 68 | X | X | X | X | X | X | X |
| | 84 | | | | X | X | X | X |
| Ceramic Leadless Chip Carrier, LCC | 28 | X | X | X | | | | |
| | 44 | X | X | X | X | X | X | |
| | 68 | X | X | X | X | X | X | |
| | 84 | | | | X | X | X | |
| | 124 | | | | X | X | X | |
| Ceramic Leaded Chip Carrier, LDCC | 124 | | | | P | P | P | P |
| Plastic Pin Grid Array, PPGA | 68 | X | X | X | X | X | X | |
| | 84 | | | X | X | X | X | |
| | 124 | | | | X | X | X | X |
| Ceramic Pin Grid Array, PGA | 68 | X | X | X | X | X | X | |
| | 84 | | | X | X | X | X | |
| | 124 | | | | X | X | X | |

X = Available Now P = prototypes only

## Packaging Information Standard Cells



# Interface

For additional Interface products, see page 239.

# Transmission Line Drivers/Receivers

The common purpose of transmission line drivers and receivers is to transmit data quickly and reliably through a variety of environments over electrically long distances. This task is complicated by the fact that externally introduced noise and ground shifts can severely degrade the data.

The connection between two elements in a system should be considered a transmission line if the transmitted signal takes longer than twice its rise or fall time to travel from the driver to the receiver.

## Single-Ended Data Transmission

In data processing systems today there are two basic means of communicating between components. One method is single-ended, which uses one signal line for data transmission, and the other is differential, which uses two signal lines.

The Electronics Industry Association (EIA) has developed several standards to simplify the interface in data communications systems.

### RS-232

The first of these, RS-232, was introduced in 1962 and has been widely used throughout the industry. RS-232 was developed for single-ended data transmission at relatively slow data rates (20 kbaud) over short distances (up to 50 ft.).

### RS-423

With the need to transmit data faster and over longer distances, RS-423, a newer standard for single-ended applications, was established. RS-423 extends the maximum data rate to 100 kbaud (up to 30 ft.) and the maximum distance to 4000 feet (up to 1 kbaud). RS-423 also requires high impedance driver outputs with power off so as not to load the transmission line.

## Differential Data Transmission

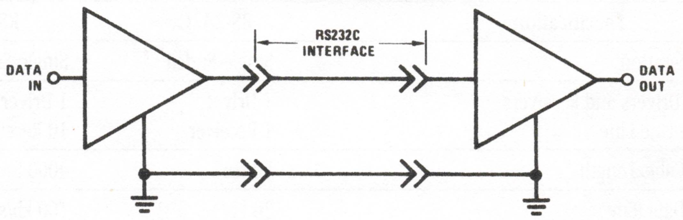
When transmitting at very high data rates, over long distances and through noisy environments, single-ended transmission is often inadequate. In these applications, differential transmission nullifies the effects of ground shifts and noise signals which appear as common-mode voltages on the transmission line.

### RS-422

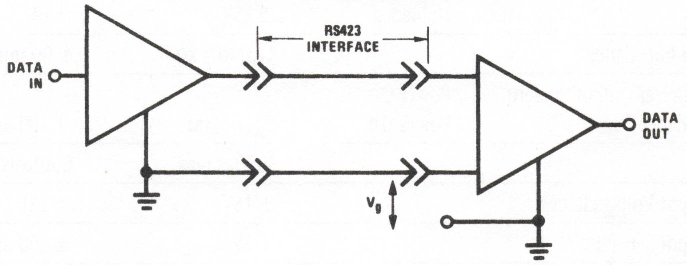
RS-422 was defined by the EIA for this purpose and allows data rates up to 10 Mbaud (up to 40 ft.) and line lengths up to 4000 feet (up to 100 kbaud).

Drivers designed to meet this standard are well suited for party-line type applications where only one driver is connected to, and transmits on, a bus and up to 10 receivers can receive the data. While a party-line type of application has many uses, RS-422 devices cannot be used to construct a truly multipoint bus. A multipoint bus consists of multiple drivers and receivers connected to a single bus, and any one of them can transmit or receive data.

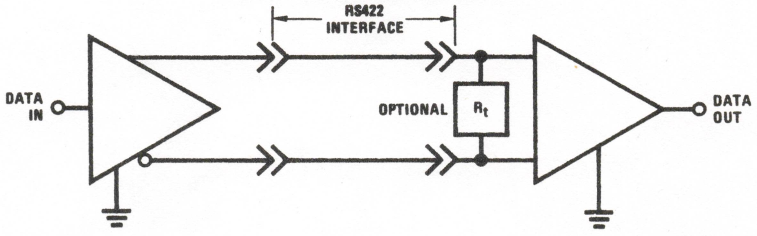
**RS-232C Application**



**EIA RS-423 Application**



**EIA RS-422 Application**



## RS-485

To meet the need for truly multipoint communications, the EIA established RS-485 in 1963. RS-485 meets all the requirements of RS-422, but in addition, this new standard allows up to 32 drivers and 32 receivers to be connected to a single bus—thus allowing a truly multipoint bus to be constructed.

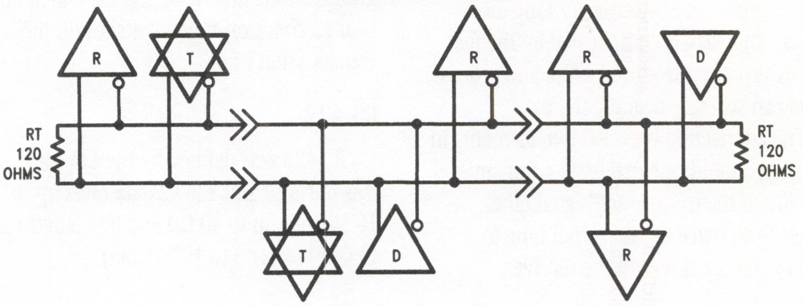
The key features of RS-485:

- Implements a truly multipoint bus consisting of up to 32 drivers and 32 receivers
- An extended common-mode range for both drivers and receivers in TRI-STATE and with power off ( − 7V to + 12V)
- Drivers can withstand bus contention and bus faults

National Semiconductor produces a variety of drivers, receivers, and transceivers for these four very popular transmission standards and numerous other data transmission requirements.

Shown below is a table that highlights key aspects of the EIA Standards.

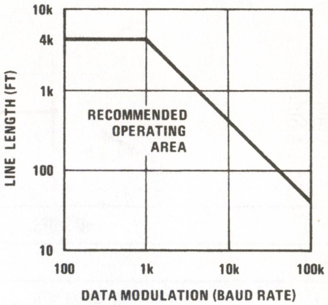
**RS-485 Application**



| Specification | | RS-232C | RS-423 | RS-422 | RS-485 |
|---|---|---|---|---|---|
| Mode of Operation | | Single-Ended | Single-Ended | Differential | Differential |
| Number of Drivers and Receivers Allowed on One Line | | 1 Driver,<br>1 Receiver | 1 Driver,<br>10 Receivers | 1 Driver,<br>10 Receivers | 32 Drivers,<br>32 Receivers |
| Maximum Cable Length | | 50 feet | 4000 feet | 4000 feet | 4000 feet |
| Maximum Data Rate | | 20 kb/s | 100 kb/s | 10 Mb/s | 10 Mb/s |
| Driver Output Maximum Voltage | | ± 25V | ± 6V | − 0.25 to + 6V | − 7V to + 12V |
| Driver Output Signal Level | Loaded | ± 3.6V | ± 3.6V | ± 2V | ± 1.5V |
| | Unloaded | ± 15V | ± 6V | ± 5V | ± 5V |
| Driver Load Impedance | | 3 kΩ to 7 kΩ | 450Ω min | 100Ω | 54Ω |
| Maximum Driver Output Current (High Impedance State) | Power On | — | — | — | ± 100 μA |
| | Power Off | $V_{MAX}$/300Ω | ± 100 μA | ± 100 μA | ± 100 μA |
| Slew Rate | | 30 V/μs max | Controls Provided | — | — |
| Receiver Input Voltage Range | | ± 15V | ± 12V | − 7V to + 7V | − 7V to + 12V |
| Receiver Input Sensivity | | ± 3V | ± 200 mV | ± 200 mV | ± 200 mV |
| Receiver Input Resistance | | 3 kΩ to 7 kΩ | 4 kΩ min | 4 kΩ min | 12 kΩ min |

## Unbalanced Single-Ended Transmission Line Drivers and Receivers

Line length is a function of data rate (baud) and slew rate. The recommended safe operating area (line length vs baud rate) is shown below for 24 AWG wire. It assumes that a differential line receiver is used which is referenced at the driver ground. Also, it assumes that the driver slew rate is between 0.1 to 0.3 times the reciprocal of the baud rate (minimum unit interval). Otherwise, line lengths greater than 50 feet are not recommended. The exception to line length is the 360 I/O coaxial interface. The coaxial provides improved grounding and eliminates crosstalk.



### Unbalanced Drivers

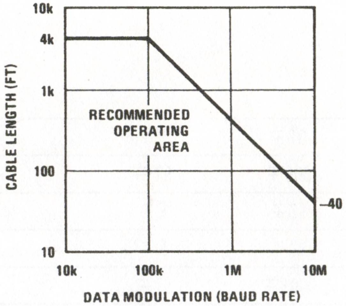
| | Device Number and Temperature Range | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Standard | Commercial 0°C to + 70°C | Military − 55°C to + 125°C | Circuits Per Package | Power Supplies (V) | Open-Collector/ Open-Emitter TRI-STATE | Party-Line Application | Slew Rate Control | Output Current (mA) | Output Voltage (V) | Propagation Delay (ns) | Comments | Package Type |
| RS-232 | DS1488 | | 4 | ± 9 or ± 15 | | | IOS/C | ± 6 | ± 6 or ± 9 | 200 | | J, M, N |
| RS-232 | DS14C88 | | | ± 9 or ± 15 | | | Internal | ± 6 | ± 7 or ± 11 | | | J, M, N |
| RS-232 | DS75150 | | 2 | ± 12 | | | IOS/C | ± 10 | ± 5 | 60 | | J, M, N |
| RS-423 | DS3691 | DS1691A | 4 | + 5 or ± 5 | TRI-STATE | Yes | CEXT | ± 20 | ± 2 | 200 | | J, M, N |
| MIL-188-114 | DS3692 | DS1692 | 4 | + 5 or ± 5 | TRI-STATE | Yes | CEXT | ± 20 | ± 2 | 200 | ± 10V Common-Mode Range | J, N |
| 360 I/O | DS75121 | DS55121 | 2 | 5 | Emitter | Yes | | − 100 | 2.4 | 10 | 50Ω Coax Driver | J, N |
| 360 I/O | DS75123 | | 2 | 5 | Emitter | Yes | | − 100 | 2.4 | 10 | 50Ω Coax Driver (IBM) | J, N |
| | DS75450 | | 2 | 5 | Emitter and Collector | Yes | | 300 | 0.7 | 20 | | J, N |
| | DS75451 | DS55451 | 2 | 5 | Collector | Yes | | 300 | 0.7 | 18 | | J, M, N |
| | DS75452 | DS55452 | 2 | 5 | Collector | Yes | | 300 | 0.7 | 26 | | J, M, N |
| | DS75453 | DS55453 | 2 | 5 | Collector | Yes | | 300 | 0.7 | 18 | | J, M, N |
| | DS75454 | DS55454 | 2 | 5 | Collector | Yes | | 300 | 0.7 | 27 | | J, M, N |

## Unbalanced Receivers

| Standard | Device Number and Temperature Range |  | Circuits Per Package | Power Supplies (V) | Strobed or TRI-STATE | Response Control | Hysteresis (mV) | Input Range (V) | Threshold Sensitivity (V) | Propagation Delay (ns) | Comments | Package Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Commercial 0°C to + 70°C | Military − 55°C to + 125°C |  |  |  |  |  |  |  |  |  |  |
| RS-232 | DS1489 |  | 4 | 5 |  | CEXT | 250 | ± 25 | 3 | 30 |  | J, M, N |
| RS-232 | DS1489A |  | 4 | 5 |  | CEXT | 1150 | ± 25 | 3 | 30 | Preferential in Applications to DS1489 | J, M, N |
| RS-232 | DS14C89A |  | 4 | 5 |  |  |  | ± 25 | 3 |  |  | J, M, N |
| RS-232 | DS75154 |  | 4 | 5 or 15 |  | CEXT | 800 | ± 25 | 3 | 22 |  | J, M, N |
| RS-423 | DS26C32 |  | 4 | 5 | TRI-STATE |  |  |  |  |  |  | J, M, N |
| RS-423 | DS26LS32C | DS26LS32M | 4 | 5 | TRI-STATE |  | 100 | ± 7 | ± 0.2 | 17 |  | J, M, N |
| RS-423 | DS26LS32AC |  | 4 | 5 | TRI-STATE |  | 100 | ± 7 | ± 0.2 | 23 | Fail-Safe | J, M, N |
| RS-423 | DS3486 |  | 4 | 5 | TRI-STATE |  | 100 | ± 15 | ± 0.2 | 25 |  | J, M, N |
| RS-423 | DS34C86 |  | 4 | 5 | TRI-STATE |  |  |  |  |  |  | J, M, N |
| RS-423 | DS88C20 | DS78C20 | 2 | 5 | Strobed | CEXT | 50 | ± 25 | ± 0.2 | 50 |  | J, N |
| RS-423 | DS88C120 | DS78C120 | 2 | 5 | Strobed | CEXT | 50 | ± 25 | ± 0.2 | 50 | Fail-Safe | J, N |
| RS-423 | DS88LS120 | DS78LS120 | 2 | 5 to 15 | Strobed | CEXT | 50 | ± 25 | ± 0.2 | 50 | Fail-Safe | J, N |
| 360 I/O | DS75124 |  | 3 | 5 | Strobed |  | 400 | 7 | 0.8 to 2 | 20 | 50Ω Coax. Receiver (IBM) | J, N |
| 360 I/O | DS75125 |  | 7 | 5 |  |  |  | − 2/7 | 0.7 to 1.7 | 16 | IBM Coax. Receiver | J, N |
| 360 I/O | DS75127 |  | 7 | 5 |  |  |  | − 2/7 | 0.7 to 1.7 | 16 | IBM Coax. Receiver | J, N |
| 360 I/O | DS75128 |  | 8 | 5 | Strobed |  |  | − 2/7 | 0.7 to 1.7 | 16 | IBM Coax. Receiver | J, N |
| 360 I/O | DS75129 |  | 8 | 5 | Strobed |  |  | − 2/7 | 0.7 to 1.7 | 16 | IBM Coax. Receiver | J, N |
|  | DS26LS33C | DS26LS33M | 4 | 5 | TRI-STATE |  | 200 | ± 15 | ± 0.5 | 17 |  | J, N, M |
|  | DS26LS33AC |  | 4 | 5 | TRI-STATE |  | 200 | ± 15 | ± 0.5 | 23 | Fail-Safe | J, N, M |

# Balanced Differential Transmission Line Drivers and Receivers

The balanced or differential scheme of data transmission is preferred for applications incorporating high data rates and long transmission lines in the presence of high common-mode noise. Induced signals appear as common-mode levels and are rejected by the differential line receiver.



## Balanced Drivers

| | Device Number and Temperature Range | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Standard | Commercial 0°C to + 70°C | Military − 55°C to + 125°C | Circuits Per Package | Power Supplies (V) | Open Collector | Party-Line Application | TRI-STATE | $V_{OH}$ (V) $I_{OH}$ (mA) | $V_{OL}$ (V) $I_{OL}$ (mA) (V) | Propagation Delay (ns) | Comments | Package Information |
| RS-422 | DS26C31 | | | | | | | | | | | J, M, N |
| RS-422 | DS26LS31C | DS26LS31M | 4 | 5 | | Yes | Yes | 2.5/ − 20 | 0.5/40 | 12 | | J, M, N |
| RS-422 | DS3487 | DS3587 | 4 | 5 | | Yes | Yes | 2.0/ − 50 | 0.5/48 | 15 | | J, M, N |
| RS-422 | DS34C87 | | | | | | | | | | | J, M, N |
| RS-422 | DS3691 | DS1691A | 2 | + 5 or ± 5 | | Yes | Yes | 2/ − 20 | − 2/20 | 200 | | J, M, N |
| RS-422 | DS8921, 21A | | 1 | 5 | | No | No | 2.5/ − 20 | 0.5/20 | 12 | Transceiver | J, M, N |
| RS-422 | DS8922<br>DS8922A | | 2 | 5 | | Yes | Yes | 2.5/ − 20 | 0.5/20 | 12 | Dual Transceiver with Driver/Receiver Pair Disable | J, M, N |
| RS-422 | DS8923<br>DS8923A | | 2 | 5 | | Yes | Yes | 2.5/ − 20 | 0.5/20 | 12 | Dual Transceiver with Separate Driver and Receiver Disables | J, M, N |
| RS-485 | DS3695 | | 1 | 5 | | Yes | Yes | | | 15 | Transceiver | M, N |
| RS-485 | DS3696 | | 1 | 5 | | Yes | Yes | | | 15 | Transceiver with Line Fault Reporting | M, N |
| RS-485 | DS3697 | | 1 | 5 | | Yes | Yes | | | 15 | Repeater | M, N |
| RS-485 | DS3698 | | 1 | 5 | | Yes | Yes | | | 15 | Repeater with Line Fault Reporting | M, N |
| RS-485 | DS75176A | | 1 | 5 | | Yes | Yes | | | | Transceiver | N, J, M |
| | DS8830 | DS7830 | 2 | 5 | | No | No | 1.8/ − 40 | 0.5/40 | 10 | | J, N |
| | DS8831 | DS7831 | 2 | 5 | | Yes | Yes | 1.8/ − 40 | 0.5/40 | 10 | | J, N |
| | DS8832 | DS7832 | 2 | 5 | | Yes | Yes | 1.8/ − 40 | 0.5/40 | 10 | DS8831 without $V_{CC}$ Clamp Diode | J, N |
| | DS8924 | | 4 | 5 | | Yes | Yes | 2.0/ − 48 | 0.5/48 | 12 | | J, N |
| | DS75113 | DS55113 | 2 | 5 | Optional | Yes | Yes | 2.0/ − 40 | 0.4/40 | 13 | | J, M, N |
| | DS75114 | DS55114 | 2 | 5 | Optional | | | 2.0/ − 40 | 0.4/40 | 15 | | J, N |
| | MM88C29 | MM78C29 | 2 | 5 or 15 | | | | 2.9/ − 57 | 0.4/11 | 100 | | J, N |
| | MM88C30 | MM78C30 | 2 | 5 or 15 | | | | 2.9/ − 57 | 0.4/11 | 100 | | J, N |

## Balanced Receivers

| Standard | Device Number and Temperature Range | | Circuits Per Package | Power Supplies (V) | Strobed or TRI-STATE | Response Control | Hysteresis (mV) | Common-Mode Range (V) | Threshold Sensitivity (V) | Propagation Delay (ns) | Comments | Package Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Commercial 0°C to + 70°C | Military − 55°C to + 125°C | | | | | | | | | | |
| RS-422 | DS26C32 | | 4 | | TRI-STATE | | | | | | | J, M, N |
| RS-422 | DS26LS32C | DS26LS32M | 4 | 5 | TRI-STATE | | 100 | ± 7 | ± 200 | 17 | | J, M, N |
| RS-422 | DS26LS32AC | | 4 | 5 | TRI-STATE | | 100 | ± 7 | ± 200 | 17 | Fail-Safe | J, M, N |
| RS-422 | DS3486 | | 4 | 5 | TRI-STATE | | 80 | ± 10 | ± 200 | 17 | | J, M, N |
| RS-422 | DS34C86 | | 4 | 5 | TRI-STATE | | | | | | | J, M, N |
| RS-422 | DS88C20 | DS78C20 | 2 | 5 to 15 | Strobed | Yes | 50 | ± 10 | ± 200 | 60 | Fail-Safe CMOS Compatible | J, N |
| RS-422 | DS88C120 | DS78C120 | 2 | 5 to 15 | Strobed | Yes | 50 | ± 10 | ± 200 | 60 | | J, N |
| RS-422 | DS88LS120 | DS78LS120 | 2 | 5 | Strobed | Yes | 50 | ± 10 | ± 200 | 50 | | J, N |
| RS-422 | DS8921 | | 1 | 5 | | | 50 | ± 7 | ± 200 | | | J, M, N |
| RS-422 | DS8921A | | 1 | 5 | | | 50 | ± 7 | ± 200 | | Low Skew | J, M, N |
| RS-422 | DS8922 | | 2 | 5 | TRI-STATE | | 50 | ± 7 | ± 200 | | | J, M, N |
| RS-422 | DS8922A | | 2 | 5 | TRI-STATE | | 50 | ± 7 | ± 200 | | Low Skew | J, M, N |
| RS-422 | DS8923 | | 2 | 5 | TRI-STATE | | 50 | ± 7 | ± 200 | | | J, M, N |
| RS-422 | DS8923A | | 2 | 5 | TRI-STATE | | 50 | ± 7 | ± 200 | | Low Skew | J, M, N |
| RS-485 | DS3695 | | 1 | 5 | TRI-STATE | | 70 | + 12/ − 7 | ± 200 | 22 | Transceiver | M, N |
| RS-485 | DS3696 | | 1 | 5 | TRI-STATE | | 70 | + 12/ − 7 | ± 200 | 22 | Transceiver with Line Fault Reporting | M, N |
| RS-485 | DS3697 | | 1 | 5 | TRI-STATE | | 70 | + 12/ − 7 | ± 200 | 22 | Repeater | M, N |
| RS-485 | DS3698 | | 1 | 5 | TRI-STATE | | 70 | + 12/ − 7 | ± 200 | 22 | Repeater with Line Fault Reporting | M, N |
| RS-485 | DS75176A | | 1 | 5 | TRI-STATE | | 70 | + 12/ − 7 | ± 200 | | Transceiver | J, M, N |
| | DS3603 | DS1603 | 2 | ± 5 | TRI-STATE | | | ± 3 | ± 25 | 17 | | J, N |
| | DS3650 | DS1650 | 4 | ± 5 | TRI-STATE | | | ± 3 | ± 25 | 10 | | J, M, N |
| | DS3652 | DS1652 | 4 | ± 5 | Strobed | | | ± 3 | ± 25 | 10 | | J, M, N |
| | DS8820 | DS7820 | 2 | 5 | Strobed | Yes | | ± 15 | ± 1000 | 40 | | J, N |
| | DS8820A | DS7820A | 2 | 5 | Strobed | Yes | | ± 15 | ± 1000 | 30 | | J, N |
| | DS75107 | DS55107 | 2 | ± 5 | Strobed | | | ± 3 | ± 25 | 17 | | J, N |
| | DS75108 | DS55108 | 2 | ± 5 | Strobed | | | ± 3 | ± 25 | 17 | | J, N |
| | DS75115 | DS55115 | 2 | 5 | Strobed | Yes | | ± 15 | ± 500 | 20 | | J, N |
| | DS75208 | | 2 | ± 5 | Strobed | | | ± 3 | ± 10 | 17 | | J, N |

# Bus Transceivers

A bus is a common communication medium, such as a cable or a printed circuit trace, that is time shared by several elements of a system. Single-ended bus circuits are listed in this section and these may be further categorized into open-collector circuits and TRI-STATE circuits.

When not transmitting, a bus driver should be capable of presenting a high impedance output in order to allow other drivers to freely use the bus. This is achieved by using either an open-collector or TRI-STATE output.

Open-collector drivers may be connected in a wired-OR configuration which is very useful for polling and bus arbitration. These devices require pull-up resistors, which can also serve as bus terminators.

TRI-STATE drivers, on the other hand, do not require bus termination for short bus runs on PC boards. In addition, TRI-STATE devices provide improved rise time characteristics with low power dissipation. Hence, they are popular in high-speed microcomputer systems.

A single-ended bus is highly susceptible to noise, including ground noise and crosstalk. For this reason the bus should not be extended beyond the subsystem's enclosure without special care. Line lengths in excess of 10 feet are not recommended without the use of noise reduction techniques, such as slew rate control, high receiver thresholds and noise filtering. Devices such as National Semiconductor's DS3662 and DS3862 Trapezoidal Bus Transceivers and DS3896 and DS3897 Future Bus Transceivers are specifically designed for reducing crosstalk and noise susceptibility on high-speed buses.

## Futurebus Transceivers

The DS3896 and DS3897 are the first two devices designed for driving high-speed microcomputer backplane buses. Both devices meet the proposed IEEE-P896 Future Bus standard and incorporate low output capacitance (<5 pF) with the ability to drive a bus with a loaded impedance of less than 18Ω. This excellent drive capability is achieved while still maintaining high levels of noise immunity.

## Power Up/Down Glitch Free Protection

Powering a device up or down, or simply connecting or disconnecting a device from an active bus, has frequently presented the design engineer with the problem of invalid data glitches being transmitted onto the bus. National Semiconductor is the industry leader in offering bus transceivers incorporating glitch-free power up/down protection. For more detailed information on National Semiconductor's line of bus transceivers, refer to the following selection guide.

## Bus Circuits

Data bus circuits are not transmission line circuits in the normal interpretation where the transmission line is electrically long (1/4 wavelength) with respect to the baud rate. Like unbalanced transmission lines, the data transmission is susceptible to common-mode noise, such as ground IR noise and induced reactive noise from crosstalk. A bus is a communications method where many elements of a system time share the same signal (address or data) bus. A bus shouldn't extend out of its subsystem's electronic enclosure without special care. Line length in excess of 10 feet is not recommended without slew rate control. Cables should be in the form of twisted pair or flat cable where a signal wire is alternated with a ground wire.

### Open-Collector Bus Circuits

| Device Number and Temperature Range | | | | Bus Driver | | Bus Receiver | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Commercial 0°C to + 70°C | Military − 55°C to + 125°C | Circuits/ Package | Driver/ Receiver/ Transceiver | Propagation Delay (ns) | $V_{OL}$ (V)/ $I_{OL}$ (mA) | Propagation Delay (ns) | $V_{IL}$ (V)/ $I_{IL}$ (μA) | $V_{IH}$ (V)/ $I_{IH}$ (μA) | Hysteresis (V) | Comments | Packaging Type |
| DM8131 | DM7131 | 1 | Receiver | | | 30 | 0.95/50 | 2/50 | 0.65 | 6-Bit Bus Comparator | J, N |
| DM8136 | DM7136 | 1 | Receiver | | | 30 | 0.95/50 | 2/50 | 0.65 | 6-Bit Bus Comparator | J, N |
| DS26S10 | DS26S10M | 4 | Transceiver | 10 | 0.8/100 | 10 | 1.75/ − 100 | 2.25/100 | | | J, N |
| DS26S11 | DS26S11M | 4 | Transceiver | 10 | 0.8/100 | 10 | 1.75/ − 100 | 2.25/100 | | Input to Bus is Non-Inverting | J, N |
| DS3662 | | 4 | Transceiver | 30 | 0.9/100 | 40 | 1.50/400 | 1.9/100 | | Trapezoidal Transceiver | J, N |
| DS3862 | | 8 | Transceiver | | | | | | | Trapezoidal Transceiver | N |
| DS3890 | | 8 | Driver | 15 | | | | | | Futurebus Driver | J, N |
| DS3892 | | 8 | Receiver | | | 18 | | | | Futurebus Receiver | J, N |
| DS3893 | | 4 | Transceiver | 7 | | 8 | | | | TURBOTRANSCEIVER | V |
| DS3896 | | 8 | Transceiver | | | | | | | Futurebus Transceiver | J, N |
| DS3897 | | 4 | Transceiver | | | | | | | Futurebus Transceiver | J, N, V |
| DS3898 | | 8 | Repeater | 30 | | | | | | Futurebus Repeater | J, N |
| DS75450 | DS55450 | 2 | Driver | 20 | 0.7/300 | | | | | AND Separate Output Transistors | J, N |
| DS75451 | DS55451 | 2 | Driver | 18 | 0.7/300 | | | | | AND | J, M, N |
| DS75452 | DS55452 | 2 | Driver | 26 | 0.7/300 | | | | | NAND | J, M, N |
| DS75453 | DS55453 | 2 | Driver | 18 | 0.7/300 | | | | | OR | J, M, N |
| DS75454 | DS55454 | 2 | Driver | 27 | 0.7/300 | | | | | NOR | J, N |
| DS8640 | DS7640 | 4 | Receiver | | | 23 | 1.2/ − 50 | 1.8/50 | | Quad NOR Receiver | J, N |
| DS8641 | DS7641 | 4 | Transceiver | 30 | 0.7/50 | 30 | 1.2/ − 100 | 1.8/100 | | | J, N |
| DS8836 | DS7836 | 4 | Receiver | | | 20 | 1.05/ − 50 | 2.65/50 | 1 | Quad NOR Receiver | J, N |
| DS8837 | DS7837 | 6 | Receiver | | | 20 | 1.05/ − 50 | 2.65/50 | 1 | | J, M, N |
| DS8838 | DS7838 | 4 | Transceiver | 25 | 0.8/50 | 30 | 1.05/ − 100 | 2.65/100 | 1 | | J, M, N |

## TRI-STATE Bus Circuits

| Device Number and Temperature Range | | | | Bus Driver | | | Bus Receiver | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Commercial 0°C to + 70°C | Military − 55°C to + 125°C | Circuits/ Package | Driver/ Receiver/ Transceiver | Propagation Delay Typ (ns) | $V_{OL}$ (V)/ $I_{OL}$ (mA) | $V_{OH}$ (V)/ $I_{OH}$ (mA) | Propagation Delay Typ (ns) | $V_{IL}$ (V) $I_{IL}$ (μA) | $V_{IH}$ (V) $I_{IH}$ (μA) | Hysteresis (mV) | Comments | Packaging Type |
| DM74S240 | DM54S240 | 4 or 8 | Transceiver | 4.5 | 0.55/64 | 2.4/ − 3 | 4.5 | 0.8/ − 400 | 2/50 | 400 | Non-Inverting | J, N |
| DM74S241 | DM54S241 | 4 or 8 | Transceiver | 6 | 0.55/64 | 2.4/ − 3 | 6 | 0.8/ − 400 | 2/50 | 400 | Inverting | J, N |
| DM74S940 | DM54S940 | 8 | Transceiver | 4.5 | 0.55/64 | 2.4/ − 3 | 4.5 | 0.8/ − 400 | 2/50 | 400 | Non-Inverting | J, N |
| DM74S941 | DM54S941 | 8 | Transceiver | 6 | 0.55/64 | 2.4/ − 3 | 6 | 0.8/ − 400 | 2/50 | 400 | Inverting | J, N |
| DP8212 | DP8212M | 8 | Driver | 20 | 0.45/15 | 3.6/ − 1 | | | | | 8080 MPU Data Latch and Service Request f/t | J, N |
| DP8216 | DP8216M | 4 | Transceiver | 20 | 0.6/55 | 3.6/ − 1 | 15 | 0.95/ − 250 | 2/10 | | 8080 MPU Non-Inverting | J, N |
| DP8226 | DP8226M | 4 | Transceiver | 16 | 0.6/50 | 3.6/ − 1 | 15 | 0.95/ − 250 | 2/10 | | 8080 MPU Inverting | J, N |
| DP8228 | DP8228M | 8 | Transceiver | 30 | 0.45/10 | 2.4/ − 1 | 20 | 0.8/ − 250 | 2/20 | | 8080 MPU System Bus Controller and Bus Driver | J, N |
| DP8238 | DP8238M | 8 | Transceiver | 30 | 0.45/10 | 2.4/ − 1 | 20 | 0.8/ − 250 | 2/20 | | 8080 MPU System Bus Controller and Bus Driver | J, N |
| DP8303A | | 8 | Transceiver | 10 | 0.5/50 | 3.6/ − 5 | 10 | 0.8/ − 250 | 2/80 | | Bidirectional Inverting | J, N |
| DP8304B | DP7304B | 8 | Transceiver | 10 | 0.5/50 | 3.6/ − 5 | 15 | 0.8/ − 250 | 2/80 | | Bidirectional Non-Inverting IEEE 488 | J, N, M |
| DP83BC04 | | 8 | Transceiver | | | | | | | | | J, N |
| DP8307A | | 8 | Transceiver | 10 | 0.5/50 | 3.6/ − 5 | 10 | 0.8/ − 250 | 2/80 | | Bidirectional Inverting | J, N |
| DP8308 | DP7308 | 8 | Transceiver | 11 | 0.5/50 | 3.6/ − 5 | 15 | 0.8/ − 250 | 2/80 | | Bidirectional Non-Inverting | J, N |
| DP83BC08 | | 8 | Transceiver | | | | | | | | | J, N |
| DS3647 | | 4 | Transceiver | 8 | 0.5/50 | 2.4/ − 5 | 7 | 0.8/ − 500 | 2/100 | | Quad Bidirectional I/O Register | D, N |
| DS3666 | | 8 | Transceiver | 20 | 0.5/48 | 2.5/ − 5.2 | 20 | 0.8/ − 100 | 2/20 | 400 | IEEE 488 GPIB | N |
| DS3667 | | 8 | Transceiver | 20 | 0.5/48 | 2.5/ − 5.2 | 20 | 0.8/ − 100 | 2/20 | 400 | | |
| DS75160A | | 8 | Transceiver | 20 | 0.5/48 | 2.5/ − 5.2 | 20 | 0.8/ − 100 | 2/20 | 400 | IEEE 488 GPIB | N |
| DS75161A | | 8 | Transceiver | 20 | 0.5/48 | 2.5/ − 5.2 | 20 | 0.8/ − 100 | 2/20 | 400 | IEEE 488 GPIB | N |
| DS75162A | | 8 | Transceiver | 20 | 0.5/48 | 2.5/ − 5.2 | 20 | 0.8/ − 100 | 2/20 | 400 | IEEE 488 GPIB | N |
| DS8T26A | DS8T26AM | 4 | Transceiver | 14 | 0.5/48 | 2.4/ − 10 | 14 | 0.85/ − 200 | 2/20 | | Inverting | J, N |
| DS8T28 | DS8T28M | 4 | Transceiver | 17 | 0.5/48 | 2.4/ − 10 | 17 | 0.85/ − 200 | 2/20 | | Non-Inverting | J, N |
| DS8833 | DS7833 | 4 | Transceiver | 14 | 0.5/50 | 2.4/ − 10 | 20 | 0.8/ − 40 | 2/80 | 400 | Non-Inverting TRI-STATE Receiver | J, N |
| DS8834 | DS7834 | 4 | Transceiver | 14 | 0.5/50 | 2.4/ − 10 | 20 | 0.8/ − 40 | 2/80 | 400 | Inverting | J, N |
| DS8835 | DS7835 | 4 | Transceiver | 14 | 0.5/50 | 2.4/ − 10 | 20 | 0.8/ − 40 | 2/80 | 400 | Non-Inverting TRI-STATE Receiver | J, N |
| DS8839 | DS7839 | 4 | Transceiver | 14 | 0.5/50 | 2.4/ − 10 | 20 | 0.8/ − 40 | 2/80 | 400 | Non-Inverting | J, N |
| DS8940 | | 9 | Transceiver | | 0.5/48 | 2.5/ − 15 | | 0.8/ − 500 | 2/50 | | 9-Bit Latchable | J, N |
| DS8941 | | 9 | Transceiver | | 0.5/48 | 2.5/ − 15 | | 0.8/ − 500 | 2/50 | | 9-Bit Latchable | J, N, V |

Note: Unless otherwise specified, bus circuits listed above are TTL compatible and use 5V supplies.

# Peripheral/Power Drivers

Peripheral/power drivers is a broad definition given to interface power devices. The devices generally have open-collector output transistors that can switch hundreds of milliamps at high voltage and are driven by standard logic gates. They serve many applications including relay drivers, printer hammer drivers, lamp drivers, bus drivers, core memory drivers, voltage level translators, stepper motor drivers and solenoid drivers.

Unlike standard logic devices, peripheral drivers have many varied load situations depending on the application. This requires the design engineer to interpret device specifications in greater detail. Designers at National Semiconductor have incorporated many technically advanced and useful features into their broad line of peripheral driver devices.

Some of these features include:

- Short circuit protection at individual outputs
- Glitch-free power up/down
- Fail-safe operation
- Inductive fly-back protection
- Negative transient protection
- High input impedance for CMOS/NMOS compatibility

For further information on National Semiconductor's broad line of peripheral drivers, refer to the following selection guide.

| Device Number and Temperature Range | | | |
|---|---|---|---|
| −55°C to +125°C | 0°C to +70°C | Description | Packaging Information |
| DP7310 | DP8310 | Octal Latched Peripheral Drivers | J, N |
| *DP7311 | DP8311 | Octal Latched Peripheral Drivers | J, N |
| *DS1631 | DS3631 | Dual AND CMOS Peripheral Driver | J, N, H |
| *DS1632 | DS3632 | Dual NAND CMOS Peripheral Driver | J, N, H |
| DS1633 | DS3633 | Dual OR CMOS Peripheral Driver | J, N, H |
| *DS1634 | DS3634 | Dual NOR CMOS Peripheral Driver | J, N, H |
| — | DS3654 | Printer Solenoid Driver | J, N |
| — | DS3656 | Quad Peripheral Driver | N |
| — | DS3658 | Quad High Current Peripheral Driver | N |
| — | DS3668 | Quad High Current Peripheral Driver | N |
| — | DS3669 | Quad High Current Peripheral Driver | N |
| — | DS3680 | Quad Negative Voltage Relay Driver | J, M, N |
| — | DS3686 | Dual Positive Voltage Relay Driver | H, J, N |
| *DS1687 | DS3687 | Dual Negative Voltage Relay Driver | H, J, N |
| — | DS75450 | Dual AND Peripheral Driver | J, N |
| *DS55451 | DS75451 | Dual AND Peripheral Driver | J, M, N |
| *DS55452 | DS75452 | Dual NAND Peripheral Driver | J, M, N |
| *DS55453 | DS75453 | Dual OR Peripheral Driver | J, M, N |
| DS55454 | DS75454 | Dual NOR Peripheral Driver | J, M, N |
| DS55461 | DS75461 | Dual AND Peripheral Driver | J, N, H |
| *DS55462 | DS75462 | Dual NAND Peripheral Driver | J, N, H |
| *DS55463 | DS75463 | Dual OR Peripheral Driver | J, N, H |
| *DS55464 | DS75464 | Dual NOR Peripheral Driver | J, N, H |
| — | MM74C908 | Dual CMOS 30V Driver | N |
| — | MM74C918 | Dual CMOS 30V Driver | N, J |

*Also available processed to various Military screening levels.

# Memory Support

MOS memory devices today can be found in a variety of configurations, giving design engineers more flexibility than ever before. National Semiconductor offers a variety of key devices that will allow a user to easily implement memory designs which meet his or her particular requirements.

National's memory support circuits include clock drivers, 4k and 16k RAM address drivers, data I/O circuits, and timing and control drivers. In addition to further information on the specific device types outlined, useful application note on "Applying Modem Clock Drivers to MOS Memories", AN-76, should be reviewed.

| Device Number and Temperature Range | | | |
|---|---|---|---|
| – 40°C to + 125°C | 0°C to + 70°C | Description | Packaging Information |
| — | DP84240 | Octal TRI-STATE MOS Driver | J, N |
| — | DP84244 | Octal TRI-STATE MOS Driver | J, N |
| — | DS0025C | Two Phase MOS Clock Driver | H, J, N |
| *DS0026 | DS0026C | 5 MHz Two Phase MOS Clock Driver | H, J, N |
| *DS0056 | DS0056C | 5 MHz Two Phase MOS Clock Driver | H, J, N |
| — | DS3245 | Quad MOS Clock Driver | J, N |
| DS1628 | DS3628 | Octal TRI-STATE MOS Driver | J, N |
| DS1645 | DS3645 | Hex TRI-STATE MOS Latch/Driver | J, N |
| — | DS3647A | Quad TRI-STATE MOS Memory I/O Register | D, N |
| DS1648 | DS3648 | TRI-STATE TTL to MOS Multiplexer/Driver | J, N |
| *DS1649 | DS3649 | Hex TRI-STATE TTL to MOS Driver | J, N |
| *DS1651 | DS3651 | Quad High Speed MOS Sense Amplifier | J, N |
| *DS1674 | DS3674 | Quad TTL to MOS Clock Driver | J, N |
| DS1675 | DS3675 | Hex TRI-STATE MOS Latch Driver | J, N |
| DS1678 | DS3678 | TRI-STATE TTL to MOS Multiplexer/Driver | J, N |
| *DS1679 | DS3679 | Hex TRI-STATE TTL to MOS Driver | J, N |
| DS16149 | DS36149 | Hex MOS Driver | J, N |
| *DS16179 | DS36179 | Hex MOS Driver | J, N |
| | DS75361 | Dual TTL to MOS Driver | J, N |
| | DS75365 | Quad TTL to MOS Driver | J, N |

# Level Translators/Buffers

Several different families of logic circuits are available today, each offering advantages in certain applications. This wide selection of circuit types allows the design engineer to more easily construct functions and systems which meet his specific requirements.

Each of these logic "families", however, is produced using different processes, and their specific electrical characteristics are almost always different. Interfacing between these logic families can, at times, be difficult.

National Semiconductor offers a selection of level translators which can greatly simplify this task. The following selection guide outlines the level translator circuits available.

| Device Number and Temperature Range | | | |
|---|---|---|---|
| −55°C to +125°C | 0°C to +70°C | Description | Packaging Information |
| — | DP8480 | 10k ECL to TTL Level Translator with Latch | F, J, N |
| — | DP8481 | TTL to 10k ECL Level Translator with Latch | F, J, N |
| — | DP8482 | 100k ECL to TTL Level Translator with Latch | F, J, N |
| — | DP8483 | TTL to 100k Level Translator with Latch | F, J, N |
| DS1630 | DS3630 | Hex CMOS Compatible Buffer | J, N |
| *DS7800 | DS8800 | Dual Voltage Level Translator | H |
| *DS78L12 | DS88L12 | Hex TTL-to-MOS Inverter/Interface Gate | J, N, W |
| *MM54C901 | MM74C901 | Hex Inverting TTL Buffer | J, N |
| *MM54C902 | MM74C902 | Hex Non-Inverting TTL Buffer | J, N |
| *MM54C903 | MM74C903 | Hex Inverting PMOS Buffer | J, N |
| *MM54C904 | MM74C904 | Hex Non-Inverting PMOS Buffer | J, N |
| *MM54C906 | MM74C906 | Hex Open Drain N-Channel Buffer | J |
| *MM54C907 | MM74C907 | Hex Open Drain P-Channel Buffer | N |

*Also available processed to various Military screening levels.

# CRT Controllers

## DP8350 Series of CRT Display Controllers

The DP8350 Series CRT Controllers are designed to be dedicated CRT display refresh circuits. All necessary video timing signals are provided by the DP8350, including the high-speed dot timing which is generated from an on-chip crystal oscillator. This is possible because of its bipolar processing which allows Schottky circuitry to be used for high speed logic and analog I/O functions while $I^2L$ circuitry is used for lower speed internal logic functions.

A typical DP8350 series application is a data terminal with a raster scan monitor. The DP8350 can be used in systems with or without line buffers, using character ROMs or DM86S64 latch/ROM/shift register circuits. Graphics are possible using either character generator or memory mapped graphics techniques.

The DP8350 Series CRT controllers are mask programmable. Mask programmability simplifies the function and reduces external hardware and software overhead. A list of programmable variables follows.

Mask programmability is an advantage as long as the screen format does not need to change and an existing part (ROM variation) can be used, or production quantities justify a new ROM variation. In addition to the ROM programmable variables, three on-chip registers provide for external control of the row starting address, cursor address and top-of-page address.

Standard parts are the DP8350, DP8352 and DP8353 whose sync signals are compatible with Ball Brothers TV-12 or TV-110, RS170 and Motorola M3000 series respectively.

## DP8350 CRT Controller Series Selection Guide

| Item No. | Parameter | | DP8350 Value | | DP8352 Value | | DP8353 Value | |
|---|---|---|---|---|---|---|---|---|
| 1 | Character Font Size (Reference Only) | Dots per Character (Width) | (5) | | (7) | | (7) | |
| 2 | | Scan Lines per Character (Height) | (7) | | (9) | | (9) | |
| 3 | Character Field Cell Size | Dots per Character (Width) | 7 | | 9 | | 9 | |
| 4 | | Scan Lines per Character (Height) | 10 | | 12 | | 12 | |
| 5 | Number of Video Characters per Row | | 80 | | 32 | | 80 | |
| 6 | Number of Video Character Rows per Frame | | 24 | | 16 | | 25 | |
| 7 | Number of Video Scan Lines (Item 4 × Item 6) | | 240 | | 192 | | 300 | |
| 8 | Frame Refresh Rate (Hz) | | f1 = 60 | f0 = 50 | f1 = 60 | f0 = 50 | f1 = 60 | f0 = 50 |
| 9 | Delay after Vertical Blank Start to Start of Vertical Sync (Number of Scan Lines) | | 4 | 30 | 27 | 53 | 0 | 32 |
| 10 | Vertical Sync Width (Number of Scan Lines) | | 10 | 10 | 3 | 3 | 3 | 3 |
| 11 | Interval Between Vertical Blank Start and Start of Video (Number of Scan Lines of Video Blanking) | | 20 | 72 | 68 | 120 | 20 | 84 |
| 12 | Total Scan Lines per Frame (Item 7 + Item 11) | | 260 | 312 | 260 | 312 | 320 | 384 |
| 13 | Horizontal Scan Frequency (Line Rate) (Item 8 × Item 12) | | 15.6 kHz | | 15.6 kHz | | 19.20 kHz | |
| 14 | Number of Character Times per Scan Line | | 100 | | 50 | | 102 | |
| 15 | Character Clock Rate (Item 13 × Item 14) | | 1.56 MHz | | 0.78 MHz | | 1.9584 MHz | |
| 16 | Character Time (1 ÷ Item 15) | | 641 ns | | 1282 ns | | 510.6 ns | |
| 17 | Delay after Horizontal Blank Start to Horizontal Sync Start | | 0 | | 6 | | 5 | |
| 18 | Horizontal Sync Width (Character Times) | | 43 | | 4 | | 9 | |
| 19 | Dot Frequency (Item 3 × Item 15) | | 10.92 MHz | | 7.02 MHz | | 17.6256 MHz | |
| 20 | Dot Time (1 ÷ Item 19) | | 91.6 ns | | 142.4 ns | | 56.7 ns | |
| 21 | Vertical Blanking Output Stop before Start of Video (Number of Scan Lines) | | 1 | | 0 | | 1 | |
| 22 | Cursor Enable on All Scan Lines of a Row? (Yes or No) | | Yes | | Yes | | Yes | |
| 23 | Does the Horizontal Sync Pulse Have Serrations during Vertical Sync? (Yes or No) | | No | | Yes | | No | |
| 24 | Width of Line Buffer Clock Logic "0" State within a Character Time (Number of Dot Time Increments) | | 4 | | 5 | | 5 | |
| 25 | Serration Pulse Width, if Used (Character Times) | | — | | 4 | | — | |
| 26 | Horizontal Sync Pulse Active State Logic Level (1 or 0) | | 1 | | 0 | | 1 | |
| 27 | Vertical Sync Pulse Active State Logic Level (1 or 0) | | 0 | | 0 | | 1 | |
| 28 | Vertical Blanking Pulse Active State Logic Level (1 or 0) | | 1 | | 1 | | 1 | |

**Video Monitor Format:** Ball Brothers TV-12, TV-120 or Equivalent. (DP8350)

**Video Monitor Format:** RS-170-Compatible (Standard American TV). (DP8352)

**Video Monitor Format:** Motorola M3003 or Equivalent. (DP8353)

## MOS/LSI Display Drivers

National's comprehensive family of display drivers encompasses more than fifteen products. The family provides direct interface to all of the common display technologies—light-emitting diode (LED), liquid crystal display (LCD), and vacuum fluorescent (VF).

### Function Similar Family

Each driver utilizes a simple serial-data input channel, on-chip shift register, latches and buffer/driver outputs. The serial input channel allows direct interface to most microprocessors, including COPs™, NSC800, 8080 series, and TMS1000 series. Besides a serial-data input, each driver requires a clock input. Some offer a latch (data) input and/or data output for easy cascade interconnect of additional drivers.

Once loaded, the shift register data can be transferred to the on-chip latches, which then output to the buffer/driver and respective display. This buffer/driver is where each provides the unique driver interface desired by the particular display technology—LED, LCD, or VF.

### The MM58241 Series—VF

Each of the six products in the MM58241 series provides high-voltage (several up to 60V) drive of VF displays. All are ideal for direct or multiplexed interface to large complex VF panel arrays or 5 × 7 (or larger) dot-matrix character strings. Each of the six drivers are cascadable for further expansion. Figure 2 illustrates that with (only) two drivers, the MM58341 and MM58348, one can interface to a 32-character (5 × 7 dot-matrix) VF display. Application note AN-371 provides further details on this and other applications.

### The MM5450 Series—LED

National's MM5450 series of LED display drivers rounds out this comprehensive product family. This popular series offers direct drive of LED displays by providing up to 25 mA of current drive per LED segment.

### Family Product Guide

Detailed features/functions of the 16-member display driver family are highlighted in the following product guide.

### CMOS/LSI

Many of the products in the display driver family utilize CMOS technology and are further evidence of National's capabilities and commitment to CMOS/LSI—the technology of the '80s.

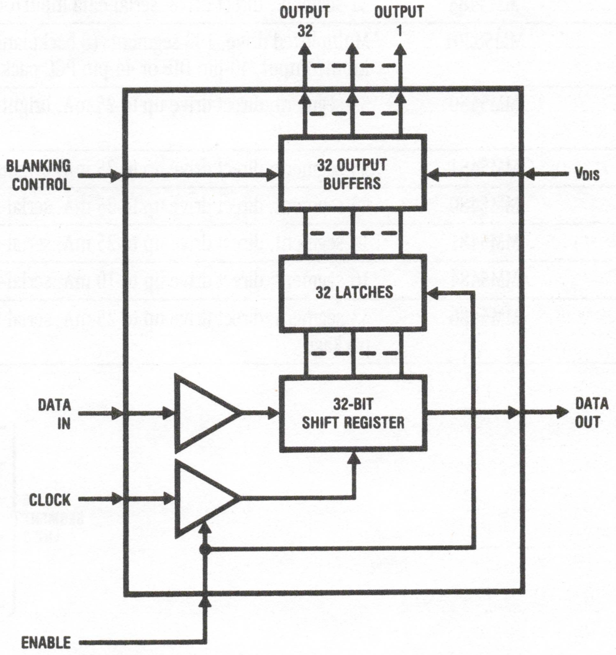


**Figure 1. Typical Block Diagram**

## LSI Display Driver Family Product Guide

| Display Technology | Product Number | Features |
|---|---|---|
| Vacuum Fluorescent (VF) | MM58241 | 32-segment, direct/multiplexed drive to 60V, data enable, brightness control, cascadable, 40-pin DIP or 44 pin PCC package |
| VF | MM58242 | 20-digit, direct/multiplexed drive to 60V, data enable, brightness control, cascadable, 28-pin DIP or PCC package |
| VF | MM58248 | 35-segment, direct/multiplexed drive to 60V, pin-compatible to MM5448, 40-pin DIP or 44-pin PCC package |
| VF | MM58341 | 32-segment, direct/multiplexed drive to 35V, data enable, brightness control, cascadable, 40-pin DIP or 44-pin PCC package |
| VF | MM58342 | 20-digit, direct/multiplexed drive to 35V, data enable, brightness control, cascadable, 28-pin DIP or PCC package |
| VF | MM58348 | 35-segment, direct/multiplexed drive to 35V, pin-compatible to MM5448, 40-pin DIP or 44-pin PCC package |
| Liquid Crystal (LCD) | MM5452 | 32-segment, direct drive, serial-data input, data enable, on-chip backplane (B/P) oscillator, 40-pin DIP or 44-pin PCC package |
| LCD | MM5453 | 33-segment, direct drive, serial-data input, B/P oscillator, 40-pin DIP or 44-pin PCC package |
| LCD | MM5483 | 31-segment, direct drive, serial-data input/output, latch (data) control, 40-pin DIP or 44-pin PCC package |
| LCD | MM58201 | Multiplexed drive, 192 segments (8 backplanes, 24 segments), 192-bit RAM, cascadable, R/C oscillator, serial-data input/output, 40-pin DIP or 44-pin PCC package |
| Light-Emitting Diode (LED) | MM5450 | 34-segment, direct drive up to 25 mA, brightness control, data enable, 40-pin DIP or 44-pin PCC package |
| LED | MM5451 | 35-segment, direct drive up to 25 mA, brightness control, 40-pin DIP or 44-pin PCC package |
| LED | MM5480 | 23-segment, direct drive up to 25 mA, serial-data input, brightness control, 28-pin DIP package |
| LED | MM5481 | 14-segment, direct drive up to 25 mA, serial-data input, brightness control, 20-pin DIP package |
| LED | MM5484 | 16-segment, direct drive up to 10 mA, serial-data input/output, cascadable, 22-pin DIP package |
| LED | MM5486 | 33-segment, direct drive up to 25 mA, serial-data input/output, brightness control, latch (data) control, 40-pin DIP package |

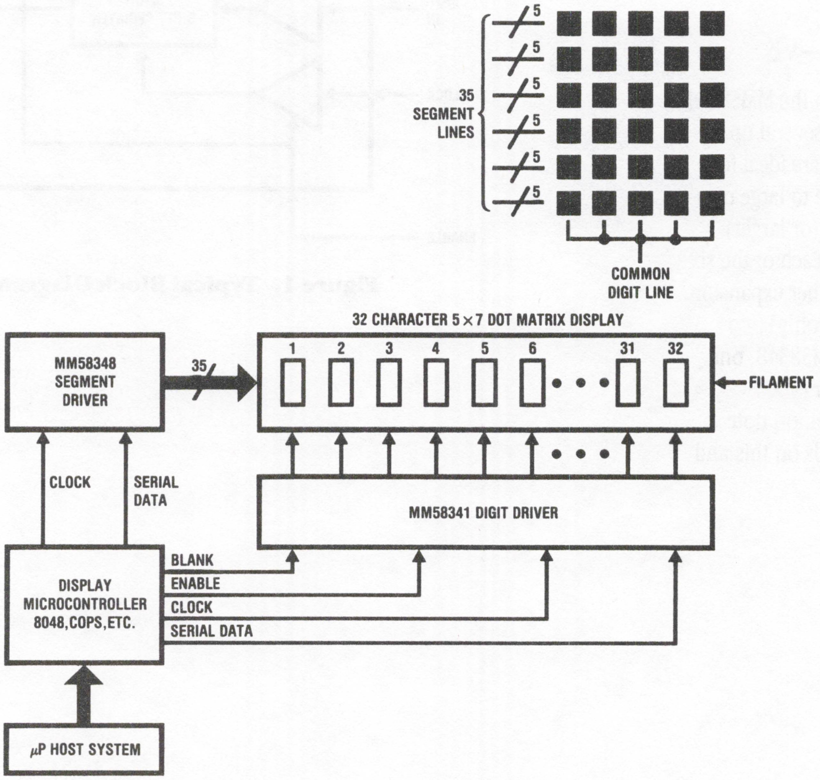

5
5
5
5
5
5
35 SEGMENT LINES
COMMON DIGIT LINE
32 CHARACTER 5 × 7 DOT MATRIX DISPLAY
1
2
3
4
5
6
31
32
FILAMENT
MM58348 SEGMENT DRIVER
35
CLOCK
SERIAL DATA
MM58341 DIGIT DRIVER
DISPLAY MICROCONTROLLER 8048,COPS,ETC.
BLANK
ENABLE
CLOCK
SERIAL DATA
µP HOST SYSTEM

**Figure 2. Typical Application of the MM58341 Series High Voltage VF Display Drivers**

# Bipolar Display Drivers

Simply stated, a display driver is an element which is used to amplify the output of a logic device in order to activate a visual display. Specific display drivers are designed to activate common anode light emitting diodes (LEDs), common cathode LEDs, gas discharge tubes and vacuum fluorescent displays.

National Semiconductor produces a variety of display drivers for all the major display technologies. Refer to the following selection guide.

### LED Display Segment Drivers

| Device Number and Temperature Range | | | $I_O$/Segment (mA) | | $V_{MAX}$ (V) | | | |
|---|---|---|---|---|---|---|---|---|
| 0°C to + 70°C | − 55°C to + 125°C | Drivers/ Package | Sink* (Common Anode) | Source (Common Cathode) | Input | Supply | Comments | Packaging Information |
| DS75491 | | 4 | 50 | 50 | 15 | 10 | | J, N |
| DS8859A | | 6 | 32 | | 5.5 | 7 | Programmable Output, Active High Latch | J, N |
| DS8867 | | 8 | | 18 | 10 | 7 | Constant Current Output | N |
| DS8654 | | 8 | | 50 | 36 | 36 | | N |

*Digit drivers with output sink capability may be used to drive segments of "common anode" displays.

### LED Display Digit Drivers

| Device Number and Temperature Range | | | $I_O$/Segment (mA) | | $V_{MAX}$ (V) | | | |
|---|---|---|---|---|---|---|---|---|
| 0°C to + 70°C | − 55°C to + 125°C | Drivers/ Package | Sink (Common Anode) | Source (Common Cathode) | Input | Supply | Comments | Packaging Information |
| DS75491 | | 4 | | 50 | 10 | 10 | | J, N |
| DS75494 | DS55494 | 6 | 150 | | 10 | 10 | Enable Control | J, N |
| DS75492 | | 6 | 250 | | 10 | 10 | | J, N |
| DS8870 | | 6 | 350 | | 10 | 10 | DS75492 Pinout, Darlington Output | J, N |
| DS8863 | | 8 | 500 | | 15 | 10 | | N |
| DS8963 | | | 500 | | 23 | 18 | | N |
| DS8654 | | | | 50 | 36 | 36 | | N |
| DS8874 | | | 50 | | 10 | 10 | Serial Shift Register Input | N |
| DS8973 | | | 100 | | 10 | 10 | 3-Cell Operation—Low Battery Indicator | N |
| DS3654 | | 10 | 400 | | 9.5 | 45 | Serial Input | J, N |

## Gas Discharge Display Drivers

| Device Number and Temperature Range | | Device | Drivers/ | | Packaging |
|---|---|---|---|---|---|
| 0°C to + 70°C | − 55°C to + 125°C | Type | Package | Comments | Information |
| DS8880 | DS7880 | Cathode Drivers | 7 | BCD to 7-Segment | J, N |
| DS8884A | | | 7 | BCD to 7-Segment with Comma and DP | N |
| DS8897A | DS7897A | | 8 | Active Low Inputs | J, N |

## Vacuum Fluorescent Display Drivers

| Device Number and Temperature Range | | Device | Drivers/ | | Packaging |
|---|---|---|---|---|---|
| 0°C to + 70°C | − 55°C to + 125°C | Type | Package | Comments | Information |
| DS8654 | | Ground Driver (segments) | 8 | 7-Segment plus DP | N |
| DS8654 | | Anode Driver (digit) | 8 | | N |
| DS8881 | | | 16 | 4 Line BCD Input | N |

## Printer Drivers

| Device Number and Temperature Range | | Device | Drivers/ | | Packaging |
|---|---|---|---|---|---|
| 0°C to + 70°C | − 55°C to + 125°C | Type | Package | Description | Information |
| DS3680 | | Mechanical | | Relay Hammer | J, M, N |
| DS3654 | | Printer | | 10 Hammer Serial Input Driver | J, N |
| DS8654 | | | | 8-Digit Driver | N |

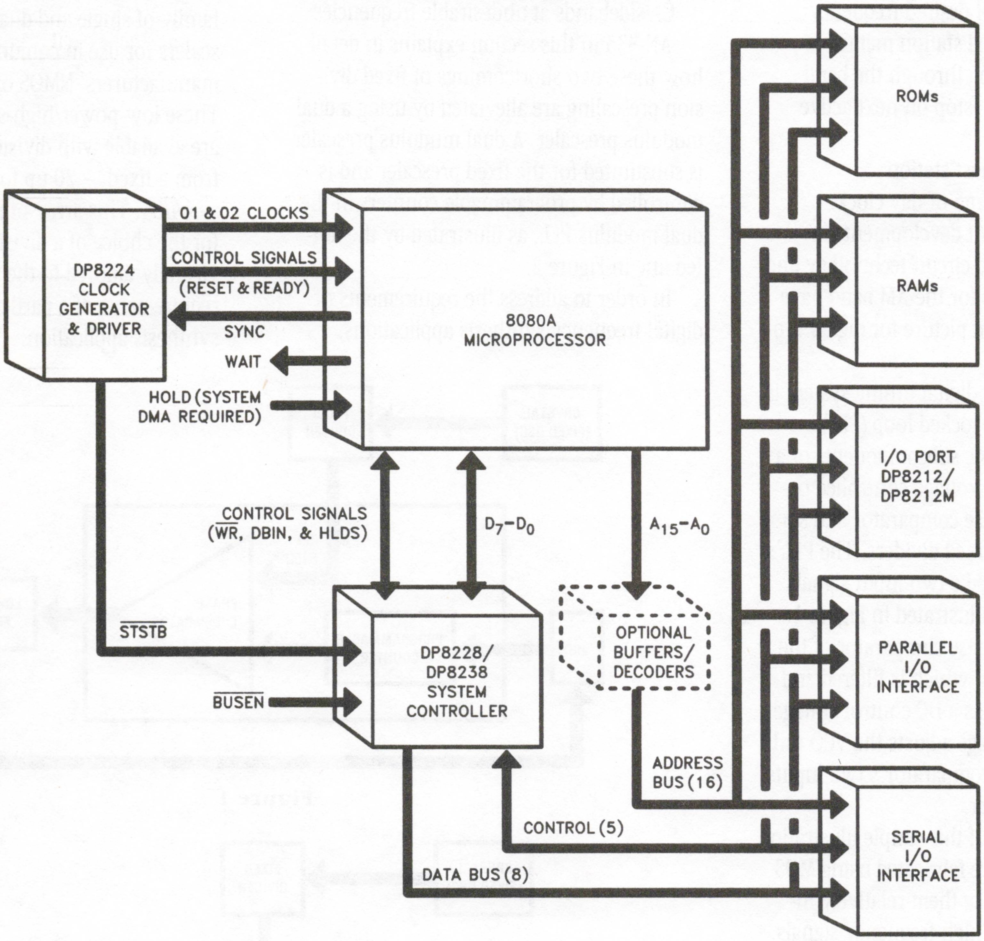
# Microprocessor Support

National offers a selection of high quality circuits designed specifically to interface with, and support, the very popular 8-bit 8080A microprocessor. National's family of 8080A support circuits includes clock/generator driver, system controller, I/O port and databus transceivers, all of which make it easy to add microprocessor capability to any system design. For further information on these devices, refer to the enclosed selection guide.

| Device Number and Temperature Range | | | |
|---|---|---|---|
| − 55°C to + 125°C | 0°C to + 70°C | Description | Packaging Information |
| DP8212M | DP8212 | 8-Bit Input/Output Port | J, N |
| DP8216M | DP8216 | 4-Bit Bidirectional Bus Transceiver | J, N |
| *DP8226M | DP8226 | 4-Bit Bidirectional Bus Transceiver | J, N |
| — | DP8224 | Clock Generator and Driver | J, N |
| *DP8228M | DP8228 | System Controller and Bus Driver | J, N |
| DS8238M | DP8238 | System Controller and Bus Driver | J, N |
| — | NS32201 | Timing Control Unit | D, N |

*Also available processed to various Military screening levels.

**National's 8080A Support Circuits**


01 & 02 CLOCKS
CONTROL SIGNALS
(RESET & READY)
DP8224
CLOCK
GENERATOR
& DRIVER
SYNC
WAIT
HOLD (SYSTEM
DMA REQUIRED)
8080A
MICROPROCESSOR
CONTROL SIGNALS
(WR, DBIN, & HLDS)
D7–D0
A15–A0
STSTB
BUSEN
DP8228/
DP8238
SYSTEM
CONTROLLER
OPTIONAL
BUFFERS/
DECODERS
ADDRESS
BUS (16)
CONTROL (5)
DATA BUS (8)
ROMs
RAMs
I/O PORT
DP8212/
DP8212M
PARALLEL
I/O
INTERFACE
SERIAL
I/O
INTERFACE

# Frequency Synthesis

Frequency synthesis is the process of generating a multitude of different frequencies from one reference frequency. A common application where the frequency synthesis concept is used is in electronically tuned radios and televisions.

Digital tuning systems are fast replacing the conventional mechanical systems in AM, FM and television receivers. The digital approach encompasses the following operational features:

- Precise tuning of station frequencies
- Exact digital frequency display
- Keyboard entry of desired frequency
- Virtually unlimited station memory
- Up/down scanning through the band
- Station "search" (stop on next active station)
- Power-on to the last station
- Easy option for time-of-day clock

In addition, recent developments in large-scale integrated circuit technology and new varactor diodes for the AM band have made the cost-benefit picture for digital tuning very attractive.

The heart of any digital tuning system is, of course, the phase locked loop (PLL) synthesizer. The basic subcomponents of a digital system are: a voltage controlled oscillator (VCO), a phase comparator and some programmable and fixed dividers. The PLL's basic function is to take two input signals and match them as illustrated in Figure 1. The output of the phase comparator of the PLL is an error signal which is filtered and fed back to the VCO as a DC control voltage. The DC control voltage adjusts the VCO until it causes the phase comparator's two inputs to match one another.

The weak point of this simple illustration is that many PLLs are fabricated using MOS processes which make them relatively incapable of receiving high frequency signals. In fact, state-of-the-art microCMOS devices are usually limited to 100 MHz operation. Even the FM band exceeds this limitation. As a result, a prescaler is almost always used in PLL tuning applications such as FM radios, police scanning radios, aircraft radios, etc. The prescaler is specifically designed to divide high frequency AC input signals down to a usable frequency for the PLL. The prescaler becomes an extension of the PLL's programmable counter as illustrated in Figure 2.

For less sophisticated tuning applications, a fixed division prescaler will make the VCO signal palatable to the PLL and be sufficient for general tuning characteristics. However, in some applications, a fixed division prescaler can cause significant undesirable side effects such as:

1. Increased channel spacing (step size) at the output of the PLL's counter; or
2. A forced decrease of the fixed oscillator reference frequency, to obtain specific channel spacing which can lead to
   A. increased lock-on time
   B. decreased scanning rates, and
   C. sidebands at undesirable frequencies

AN-335 in this section explains in detail how these two shortcomings of fixed division prescaling are alleviated by using a dual modulus prescaler. A dual mudulus prescaler is substituted for the fixed prescaler and is controlled by programmable counters in the dual modulus PLL, as illustrated by the dotted line in Figure 2.

In order to address the requirements of digital frequency synthesis applications, National has introduced a growing family of PLL synthesizers and prescalers. The DS8906, DS8907 and DS8908 are complete PLL synthesizers with features that go beyond those illustrated in Figure 2.

## Highlights

- The DS8908 integrates a reference oscillator, phase comparator, charge pump, operational amplifier, 120 MHz ECL/$I^2L$ dual modulus programmable divider, and a shift register/latch for serial data entry.
- The DS8614, DS8615, DS8616, DS8617, DS8627, and DS8628 represent a broad family of single and dual modulus prescalers for use in conjunction with other manufacturers' NMOS or CMOS PLLs. These low-power/high-speed prescalers are available with division ratios ranging from a fixed ÷ 20 up to a dual modulus ÷ 64/65. This array of products allows for the choice of a division ratio which is virtually tailored to the speed and tuning requirements of a particular frequency synthesis application.

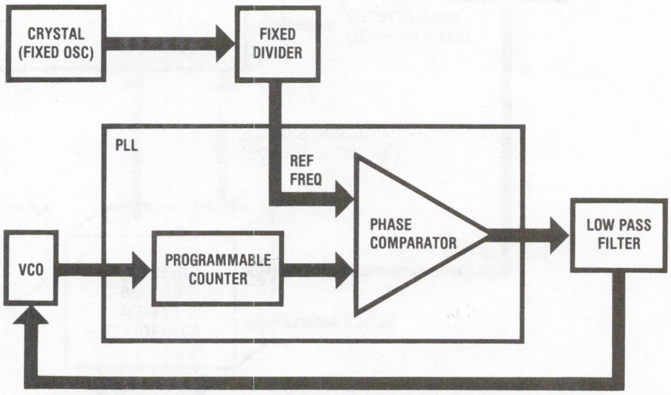


Figure 1

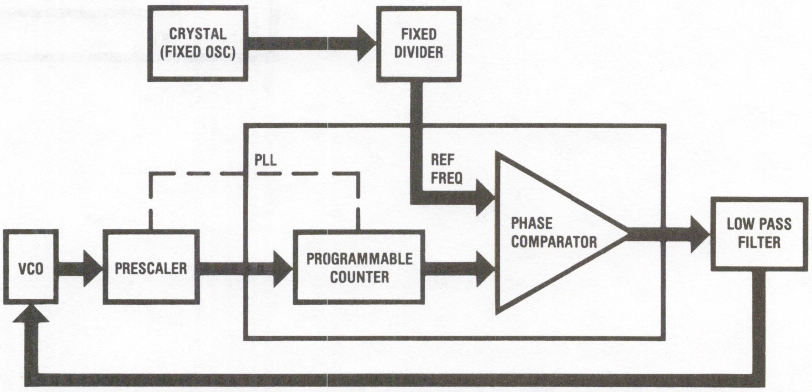


Figure 2

## Frequency Synthesis Selection Guide

| Device Number | Description | Temperature Range (°C) | Packaging Information |
|---|---|---|---|
| DS8614 | 130/225 MHz Low Power Dual Modulus Prescalers | – 30 to + 70 | N |
| DS8615 | 130/225 MHz Low Power Dual Modulus Prescalers | – 30 to + 70 | N |
| DS8616 | 130/225 MHz Low Power Dual Modulus Prescalers | – 30 to + 70 | N |
| DS8617 | 130/225 MHz Low Power Dual Modulus Prescalers | – 30 to + 70 | N |
| DS8627 | 130/225 MHz Low Power Prescalers | – 30 to + 70 | N |
| DS8628 | 130/225 MHz Low Power Prescalers | – 30 to + 70 | N |
| DS8629 | 120 MHz Divide-by-100 Prescaler | 0 to + 70 | N |
| DS8906 | AM/FM Digital Phase-Locked Loop Frequency Synthesizer | 0 to + 70 | N |
| DS8907 | AM/FM Digital Phase-Locked Loop Frequency Synthesizer | – 40 to + 85 | N |
| DS8908 | AM/FM Digital Phase-Locked Loop Frequency Synthesizer | – 40 to + 85 | N |
| DS8911 | AM/FM/TV Sound Up Conversion Frequency Synthesizer | – 40 to + 85 | M, N, V |
| DS8912 | AM/FM/TV Sound Up Conversion Frequency Synthesizer | – 40 to + 85 | M, N, V |

# Real Time Clocks The RTC Family—MM58167A, MM58174A, MM58274

National's family of Real Time Clocks (RTCs) provides a simple microprocessor bus compatible interface to any system requiring accurate, reliable, on-going real time and calendar.

## CMOS Technology—Low Power

Each device in the family develops real time from an on-chip 32.768 kHz crystal-controlled oscillator. All devices utilize metal-gate CMOS technology, which means extreme low power operation. National's CMOS allows the clock/calendar function to remain, with no time loss, on standby battery back-up when normal AC line power fails or is shut off. In power down mode these RTCs require 5$\mu$A at 2.5V, typically.

## Microprocessor Bus Compatible

The industry standard parallel address and data bus structures make National's RTC family compatible with all popular microprocessors, like NSC800, COPS, 8080 Series, 6800. Each device offers handshaking controls like Chip Select, Read and Write for simple interface to a microprocessor.

## Event Interrupts

Each RTC in the family offers timed interrupts, 0.5, 10, 30 seconds, etc. These interrupts can be active in single or repeat modes to further simplify routine system timed events. The MM58167A extends this interrupt capability with an alarm-type feature, allowing a future and real-time comparison to initiate an interrupt, i.e., a system wake-up interrupt.

## The MM58274

The newest member of National's RTC family is the MM58274. The MM58274 is pin-compatible to the industry-popular MM58174A. Easy system upgrade from the MM58174A to the MM58274 is possible with only a system software change. The MM58274 brings additional features to the family such as, a years counter, 12 or 24 hour timekeeping, extended interrupt event times, and buffered oscillator output for accurate oscillator timing. Of course, the MM58274 maintains the convenient 16-pin package and MM58174A pinouts, even with these additional features!

## Family Comparison Guide

Check the RTC comparison guide for additional features, functions, and benefits of all the family members.

## CMOS/LSI

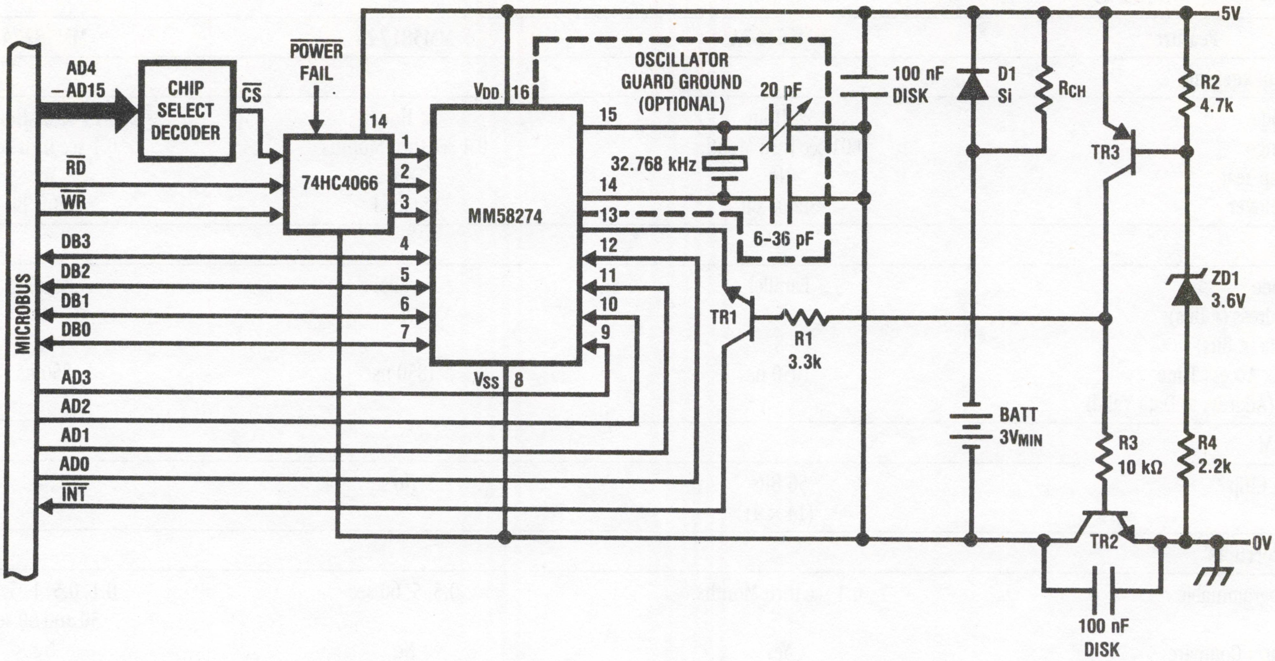
The Real-Time Clock family demonstrates National's capability and commitment to CMOS/LSI—the technology of the 80's.

## RTC Family Comparison Guide

| Features | MM58167A | MM58174A | MM58274 |
|---|---|---|---|
| **Timekeeping** | | | |
| Mode | 24 Hour | 24 Hour | 12 or 24 Hour |
| Range | 0.01 sec thru Months | 0.1 sec thru Months | 0.1 sec thru Years |
| Leap Year | No | Yes | Yes |
| Rollover | Status Bit | Data = F | Status Bit |
| **Bus** | | | |
| Mode | Parallel | Parallel | Parallel |
| Address (# Bits) | 5 | 4 | 4 |
| Data (# Bits) | 8 | 4 | 4 |
| Max Access Time (Address to Data Valid) | 1050 ns | 1850 ns | 850 ns |
| **RAM** | | | |
| On-Chip | 56 Bits<br>(14 × 4) | No | No |
| **Interrupts** | | | |
| Programmable | 0.1 sec thru Months | 0.5, 5, 60 sec | 0.1, 0.5, 1, 5, 10, 30 and 60 sec |
| Alarm Compare | Yes | No | No |
| Standby Mode | Yes | No | No |
| Status Register | Yes | No | Yes |
| **Timebase** | | | |
| Oscillator Frequency | 32.768 kHz | 32.768 kHz | 32.768 kHz |
| Buffered Oscillator Output | No | No | Yes |
| **Power Supply** | | | |
| Voltage | | | |
| Operational | 4–5.5V | 4–5.5V | 4–5.5V |
| Standby | 2.0V min | 2.2V min | 2.2V min |
| Current | | | |
| Operational | 5 mA | 1 mA | 1 mA |
| Standby ($I_{DD}$ Max) | 20 $\mu$A | 10 $\mu$A | 10 $\mu$A |
| **Process Technology** | | | |
| | CMOS | CMOS | CMOS |
| **Packaging** | | | |
| Pins/Type | 24 DIP<br>28 PCC | 16* DIP | 16* DIP<br>20 PCC |

*Same Pinouts

### Typical MM58274 RTC System Diagram


AD4
– AD15
CHIP SELECT DECODER
$\overline{CS}$
$\overline{POWER}$ FAIL
74HC4066
14
1
2
3
4
5
6
7
$V_{DD}$ 16
MM58274
$V_{SS}$ 8
15
14
13
12
11
10
9
OSCILLATOR GUARD GROUND (OPTIONAL)
20 pF
32.768 kHz
6–36 pF
TR1
R1 3.3k
100 nF DISK
D1 Si
$R_{CH}$
R2 4.7k
TR3
ZD1 3.6V
BATT $3V_{MIN}$
R3 10 kΩ
R4 2.2k
TR2
100 nF DISK
5V
0V
MICROBUS
$\overline{RD}$
$\overline{WR}$
DB3
DB2
DB1
DB0
AD3
AD2
AD1
AD0
$\overline{INT}$

# The TCP Family—DP8570, DP8571, DP8572, DP8573

National's family of Timer Clock Peripherals (TCPs) are truly advanced, next generation real time clocks (RTCs) *plus.* The TCP family offers a simple, *fast* microprocessor bus compatible interface, with valid data (150 ns max) after address valid. All offer chip select, read and write handshaking controls to complement this convenient high speed, RAM like, microprocessor bus interface.

## Programmable Timers/Interrupts —On-Chip

Two members of the TCP family offer two independent multifunction programmable 10 MHz 16-bit timers. Each timer has its own prescaler and can select any of 8 possible clock inputs. In addition, each of the family members provides a flexible array of interrupts—periodic alarm, timer and powerfail (with time save) interrupts.

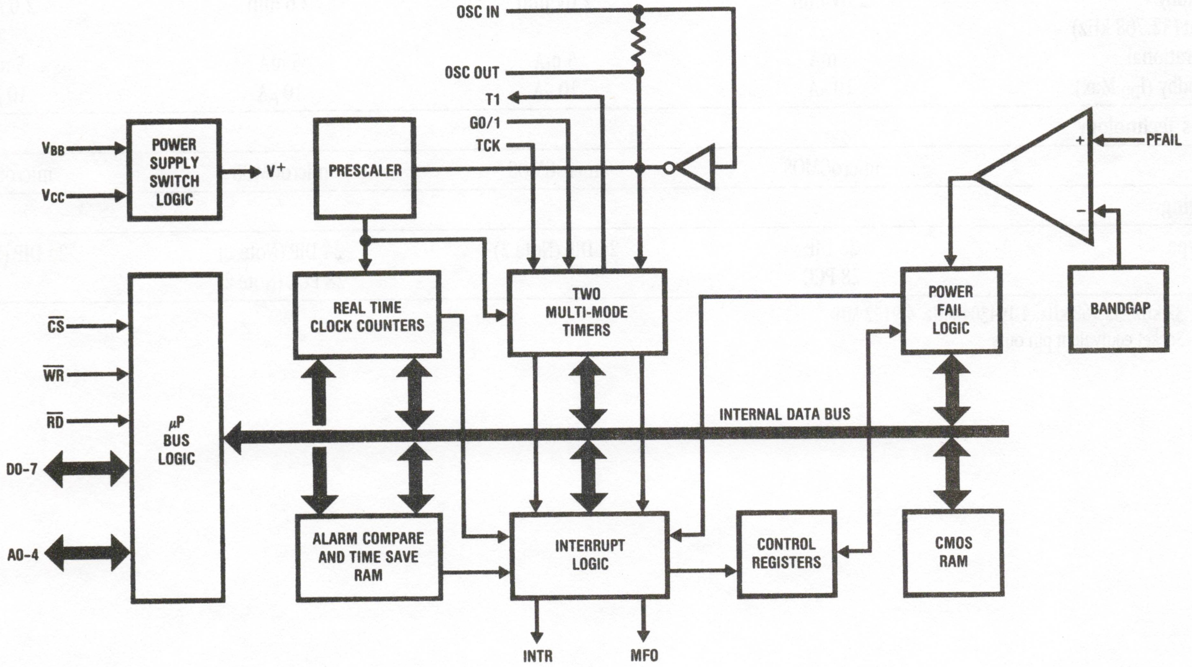
## Powerfail Detect and RAM — On-Chip

This advanced RTC family minimizes the complex external circuitry required for powerfail by integrating auto powerfail detect and transition to external battery backup on-chip. A user-selectable reference gives the system designer detect threshold flexibility with minimal external components. Many members provide up to 44 bytes of RAM to retain important system parameters during power down or for use as local memory during normal system operation.

## Advanced CMOS Technology — Low Power

The TCP family utilizes National's advanced 2-micron dual metal CMOS process to continue the tradition of extreme low power down requirements established by our RTC family, 5 μA at 2.5V typical. Finally, all are software and hardware compatible for easy system migration from clock only product needs to advanced timer clock requirements. Three members, the DP8571, DP8572, and DP8573, are socket compatible.

**DP8570 Block Diagram**

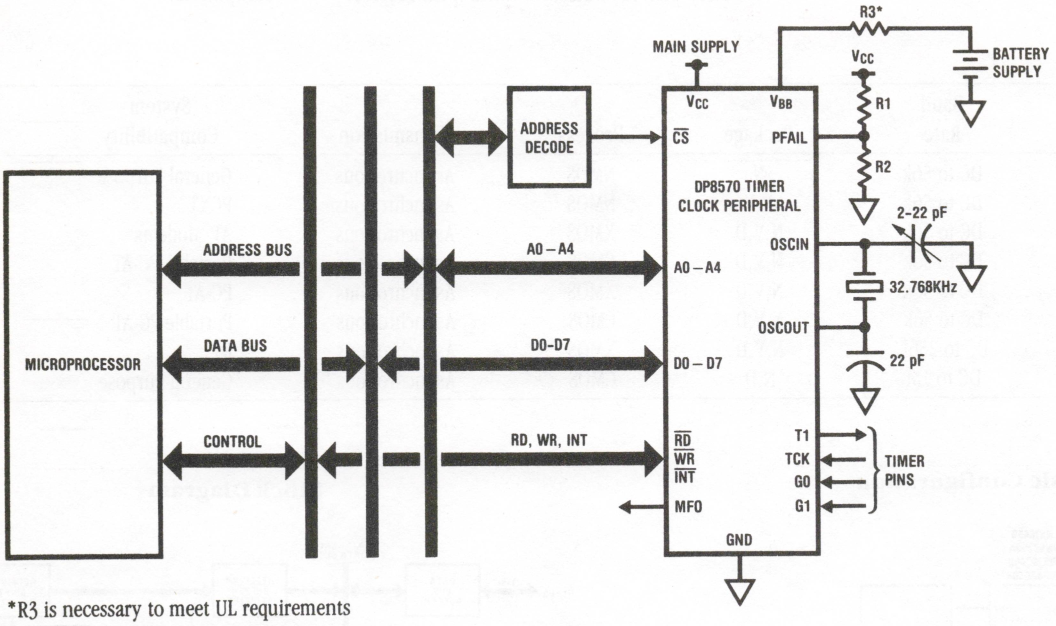

OSC IN
OSC OUT
T1
G0/1
TCK
VBB
VCC
POWER SUPPLY SWITCH LOGIC
V+
PRESCALER
PFAIL
+
-
REAL TIME CLOCK COUNTERS
TWO MULTI-MODE TIMERS
POWER FAIL LOGIC
BANDGAP
CS
WR
RD
D0-7
A0-4
μP BUS LOGIC
INTERNAL DATA BUS
ALARM COMPARE AND TIME SAVE RAM
INTERRUPT LOGIC
CONTROL REGISTERS
CMOS RAM
INTR
MFO

## TCP Family Comparison Guide

| Features | DP8570 | DP8571 | DP8572 | DP8573 |
|---|---|---|---|---|
| **Timekeeping** | | | | |
| Mode | 12 or 24 Hour | 12 or 24 Hour | 12 or 24 Hour | 12 or 24 Hour |
| Range | 0.01 sec thru Years | 0.01 sec thru Years | 0.01 sec thru Years | 0.01 sec thru Years |
| Leap Year | Yes | Yes | Yes | Yes |
| Rollover | Status Bit | Status Bit | Status Bit | Status Bit |
| **Bus** | | | | |
| Mode | Parallel | Parallel | Parallel | Parallel |
| Address (# Bits) | 5 | 5 | 5 | 5 |
| Data (# Bits) | 8 | 8 | 8 | 8 |
| Max Access Time (Address to Data Valid) | 150 ns | 150 ns | 150 ns | 150 ns |
| **RAM** | | | | |
| On-Chip | 44 Bytes | 44 Bytes | 51 Bytes | 20 Bytes |
| Timer | 2 16-Bit | 2 16-Bit | No | No |
| **Interrupts** | | | | |
| Programmable | 0.01 thru 1 sec | 0.01 thru 1 sec | 0.01 thru 1 sec | 0.01 thru 1 sec |
| Alarm Compare | Yes | Yes | Yes | Yes |
| Standby Mode | Yes | Yes | Yes | Yes |
| Status Register | Yes | Yes | Yes | Yes |
| Timer | Yes | Yes | No | No |
| **Timebase** | | | | |
| Oscillator Frequency | 4 Selectable (Note 1) | 4 Selectable (Note 1) | 32.768 kHz | 32.768 kHz |
| Buffered Oscillator Output | Yes | Yes | Yes | Yes |
| **Power Supply** | | | | |
| Voltage | | | | |
| Operational | 4.5–5.5V | 4.5–5.5V | 4.5–5.5V | 4.5–5.5V |
| Standby | 2.0V min | 2.0V min | 2.0 min | 2.0 min |
| Current (32.768 kHz) | | | | |
| Operational | 5 mA | 5 mA | 5 mA | 5 mA |
| Standby ($I_{DD}$ Max) | 10 $\mu$A | 10 $\mu$A | 10 $\mu$A | 10 $\mu$A |
| **Process Technology** | | | | |
| | microCMOS | microCMOS | microCMOS | microCMOS |
| **Packaging** | | | | |
| Pins/Type | 28 DIP<br>28 PCC | 24 DIP (Note 2) | 24 DIP (Note 2)<br>28 PCC (Note 2) | 24 DIP (Note 2) |

Note 1: 32 kHz, 32.768 kHz, 4.194304 MHz, 4.9152 MHz
Note 2: Socket equivalent pin outs

## Typical Application


R3*
MAIN SUPPLY
BATTERY SUPPLY
VCC
VCC
VBB
R1
ADDRESS DECODE
CS
PFAIL
R2
DP8570 TIMER CLOCK PERIPHERAL
2-22 pF
OSCIN
MICROPROCESSOR
ADDRESS BUS
A0 – A4
A0 – A4
32.768KHz
OSCOUT
DATA BUS
D0-D7
D0 – D7
22 pF
CONTROL
RD, WR, INT
RD
WR
INT
T1
TCK
G0
G1
TIMER PINS
MFO
GND

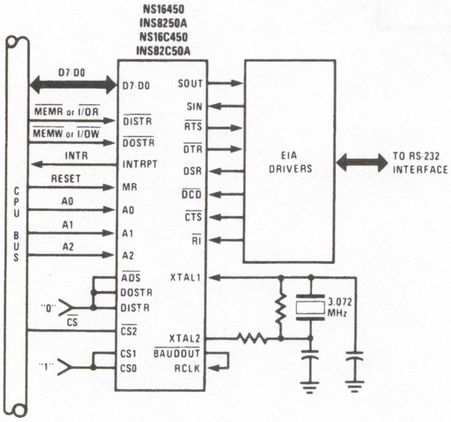
*R3 is necessary to meet UL requirements

# Serial Communication—UARTs

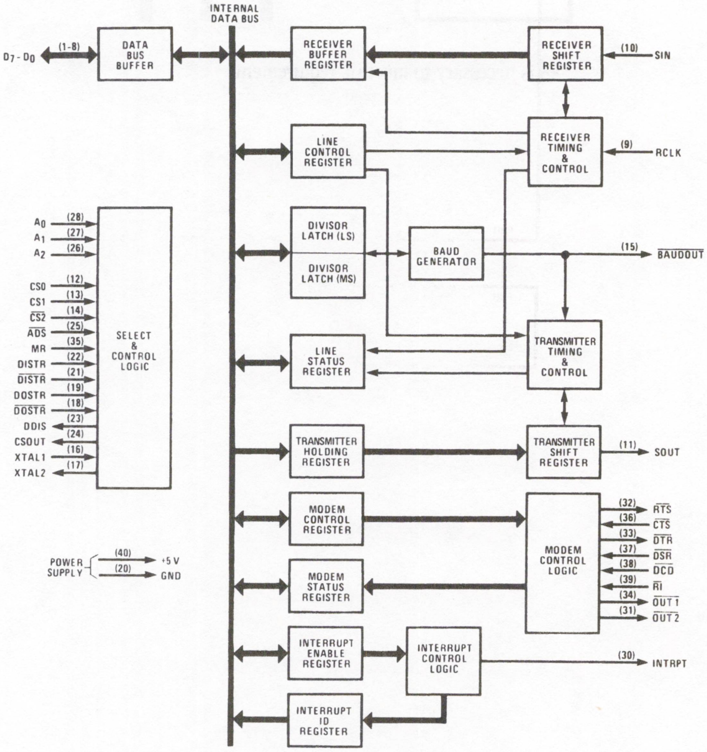
National's family of UARTs provides high performance, low power serial data input/output interface. These UARTs are built using NMOS, CMOS and XMOS technologies. They provide buffered, full duplex receiver and transmitter functions along with a programmable baud rate generator and modem control functions. In systems interfacing to IBM PCs, the 8250 and 16450 are fully IBM compatible.

| Part # | Baud Rate | Package | Process | Transmission | System Compatibility | Multiplexed Demultiplexed |
|---|---|---|---|---|---|---|
| NS8250N | DC to 56k | N | NMOS | Asynchronous | General Purpose | Demultiplexed |
| NS8250N-B | DC to 56k | N,V | NMOS | Asynchronous | PCXT | Demultiplexed |
| NS8250A | DC to 56k | N,V,D | XMOS | Asynchronous | AT, Modems | Demultiplexed |
| NS82C50A | DC to 56k | N,V,D | CMOS | Asynchronous | Portable PC-AT | Demultiplexed |
| NS16450N | DC to 56k | N,V,D | XMOS | Asynchronous | PC-AT | Demultiplexed |
| NS16C450 | DC to 56k | N,V,D | CMOS | Asynchronous | Portable PC-AT | Demultiplexed |
| NS16550 | DC to 256k | N,V,D | XMOS | Asynchronous | RT | Demultiplexed |
| NSC858 | DC to 1M | N,D | CMOS | Asynchronous | General Purpose | Multiplexed |

## Basic Configuration


NS16450
INS8250A
NS16C450
INS82C50A
CPU BUS
D7-D0
MEMR or I/OR
MEMW or I/OW
INTR
RESET
A0
A1
A2
"0"
CS
"1"
D7-D0
DISTR
DOSTR
INTRPT
MR
A0
A1
A2
ADS
DOSTR
DISTR
CS2
CS1
CS0
SOUT
SIN
RTS
DTR
DSR
DCD
CTS
RI
XTAL1
XTAL2
BAUDOUT
RCLK
EIA DRIVERS
TO RS-232 INTERFACE
3.072 MHz

## Block Diagram

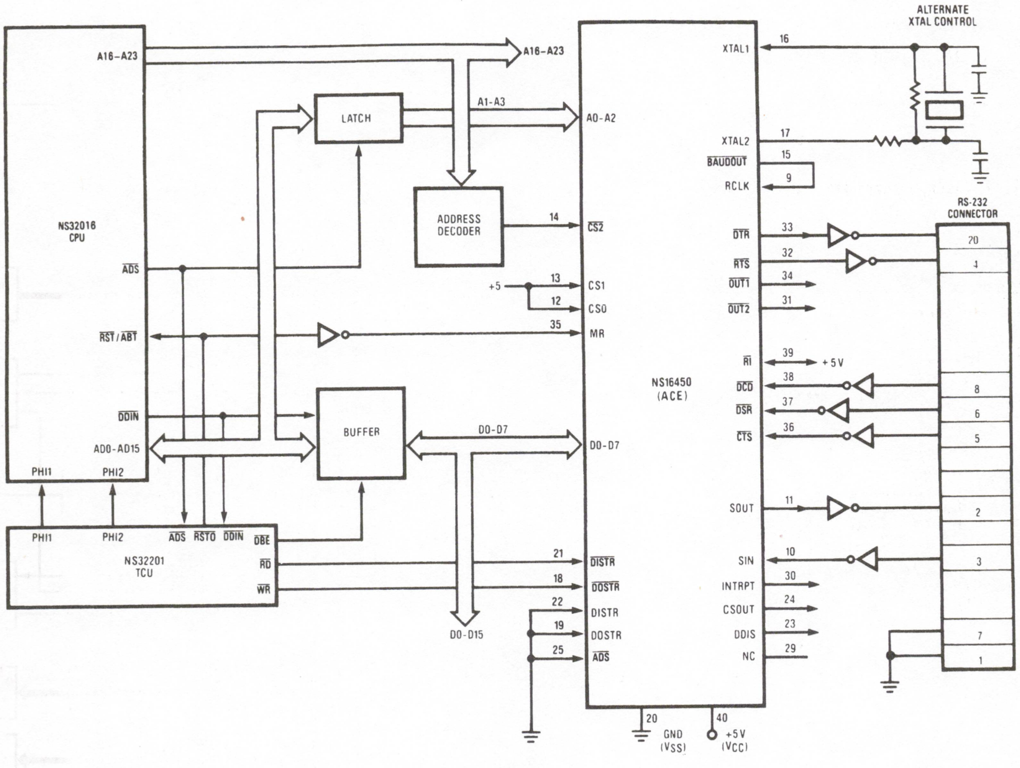

INTERNAL DATA BUS
D7-D0
(1-8)
DATA BUS BUFFER
RECEIVER BUFFER REGISTER
RECEIVER SHIFT REGISTER
(10)
SIN
LINE CONTROL REGISTER
RECEIVER TIMING & CONTROL
(9)
RCLK
DIVISOR LATCH (LS)
DIVISOR LATCH (MS)
BAUD GENERATOR
(15)
BAUDOUT
A0 (28)
A1 (27)
A2 (26)
CS0 (12)
CS1 (13)
CS2 (14)
ADS (25)
MR (35)
DISTR (22)
DISTR (21)
DOSTR (19)
DOSTR (18)
DDIS (23)
CSOUT (24)
XTAL1 (16)
XTAL2 (17)
SELECT & CONTROL LOGIC
LINE STATUS REGISTER
TRANSMITTER TIMING & CONTROL
TRANSMITTER HOLDING REGISTER
TRANSMITTER SHIFT REGISTER
(11)
SOUT
MODEM CONTROL REGISTER
MODEM CONTROL LOGIC
(32) RTS
(36) CTS
(33) DTR
(37) DSR
(38) DCD
(39) RI
(34) OUT1
(31) OUT2
POWER SUPPLY
(40) +5 V
(20) GND
MODEM STATUS REGISTER
INTERRUPT ENABLE REGISTER
INTERRUPT CONTROL LOGIC
(30)
INTRPT
INTERRUPT ID REGISTER

# Systems Components

## Serial Communication that can Complement

The serial communication function represented by the RS232C has been incorporated into many products as the standard interface of microprocessor-applied equipment. National's UART has a built-in baud rate generator and can easily be connected to a general-purpose microprocessor. The loopback diagnostic function is equipped to maintain the lines well. The interrupts have 4-level priority and can easily be handled on software by referencing the status register. National offers a high-performance UART group consisting of six devices, including the NS16450 (upper version of INS8250A) for 10 MHz 32-bit CPUs such as the Series 32000 family.

**Block Diagram**



NS32016
CPU
A16–A23
$\overline{\text{ADS}}$
$\overline{\text{RST}}/\overline{\text{ABT}}$
$\overline{\text{DDIN}}$
AD0–AD15
PHI1
PHI2
LATCH
A1-A3
ADDRESS
DECODER
BUFFER
D0-D7
D0-D15
PHI1
PHI2
$\overline{\text{ADS}}$
$\overline{\text{RSTO}}$
$\overline{\text{DDIN}}$
$\overline{\text{DBE}}$
$\overline{\text{RD}}$
$\overline{\text{WR}}$
NS32201
TCU
+5
A16–A23
A0-A2
14
$\overline{\text{CS2}}$
13
CS1
12
CS0
35
MR
D0-D7
21
$\overline{\text{DISTR}}$
18
$\overline{\text{DOSTR}}$
22
DISTR
19
DOSTR
25
$\overline{\text{ADS}}$
NS16450
(ACE)
20
GND
(VSS)
40
+5V
(VCC)
XTAL1
16
XTAL2
17
$\overline{\text{BAUDOUT}}$
15
RCLK
9
ALTERNATE
XTAL CONTROL
$\overline{\text{DTR}}$
33
$\overline{\text{RTS}}$
32
$\overline{\text{OUT1}}$
34
$\overline{\text{OUT2}}$
31
$\overline{\text{RI}}$
39
+5V
$\overline{\text{DCD}}$
38
$\overline{\text{DSR}}$
37
$\overline{\text{CTS}}$
36
SOUT
11
SIN
10
INTRPT
30
CSOUT
24
DDIS
23
NC
29
RS-232
CONNECTOR
20
4
8
6
5
2
3
7
1

# Linear

For additional Linear products, see pages 247 and 431.

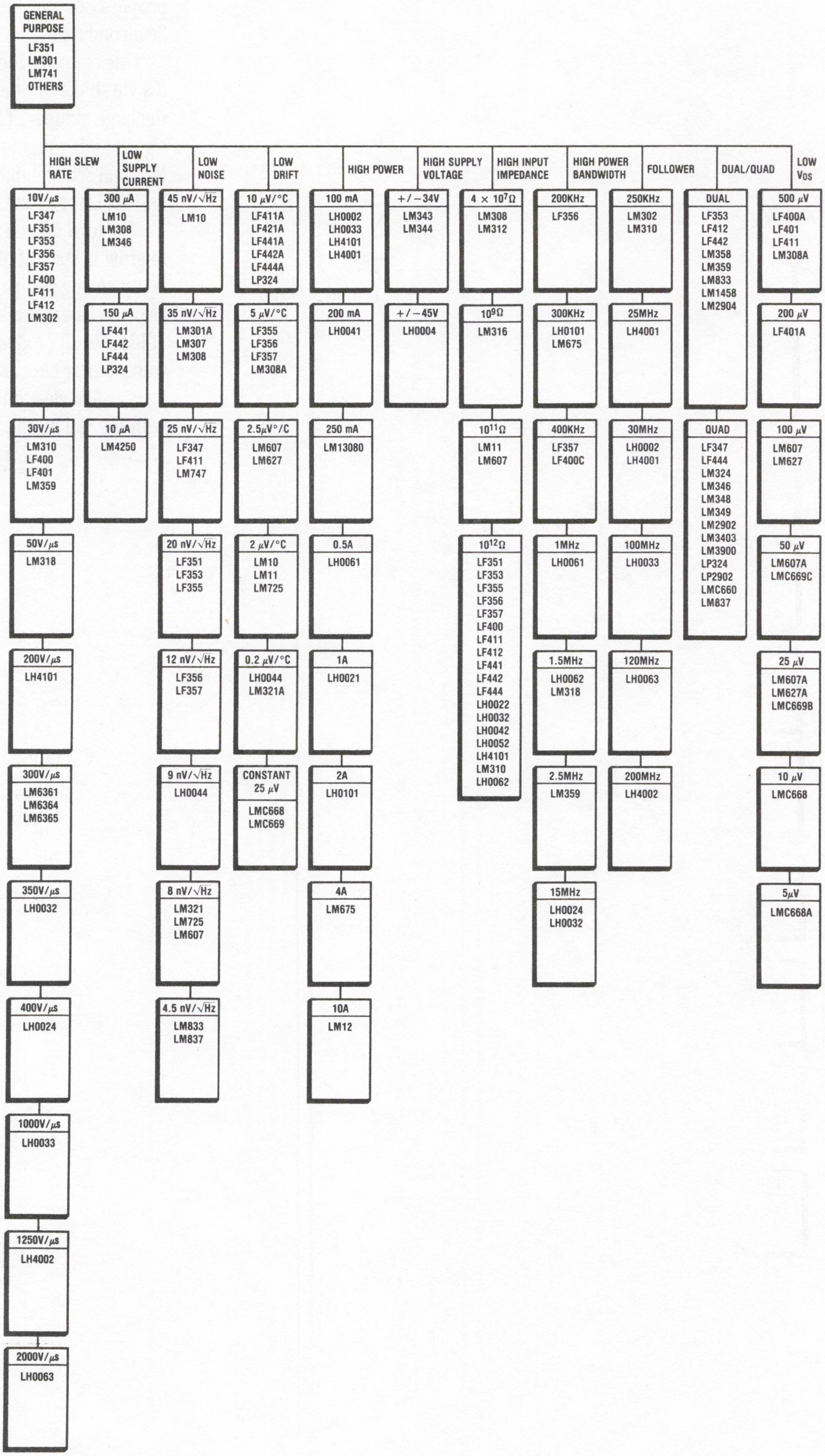
# Linear Family

National Semiconductor and Linear ICs are synonymous. Why do so many people associate Linear with National Semiconductor?

One reason is the large number of Linear ICs we ship every year. Another reason is the large number of Linear ICs that were designed and brought into production by National Semiconductor, such as the LM324, LM358, LM311, LM317 and many others.

The total market for Linear ICs continues to grow in spite of digital designs replacing many analog systems. The reason for the growing Linear market is the pervasiveness of ICs into all product areas and new innovative Linear circuits that allow an increasingly digital electronic world to interface with the real world, which is analog.

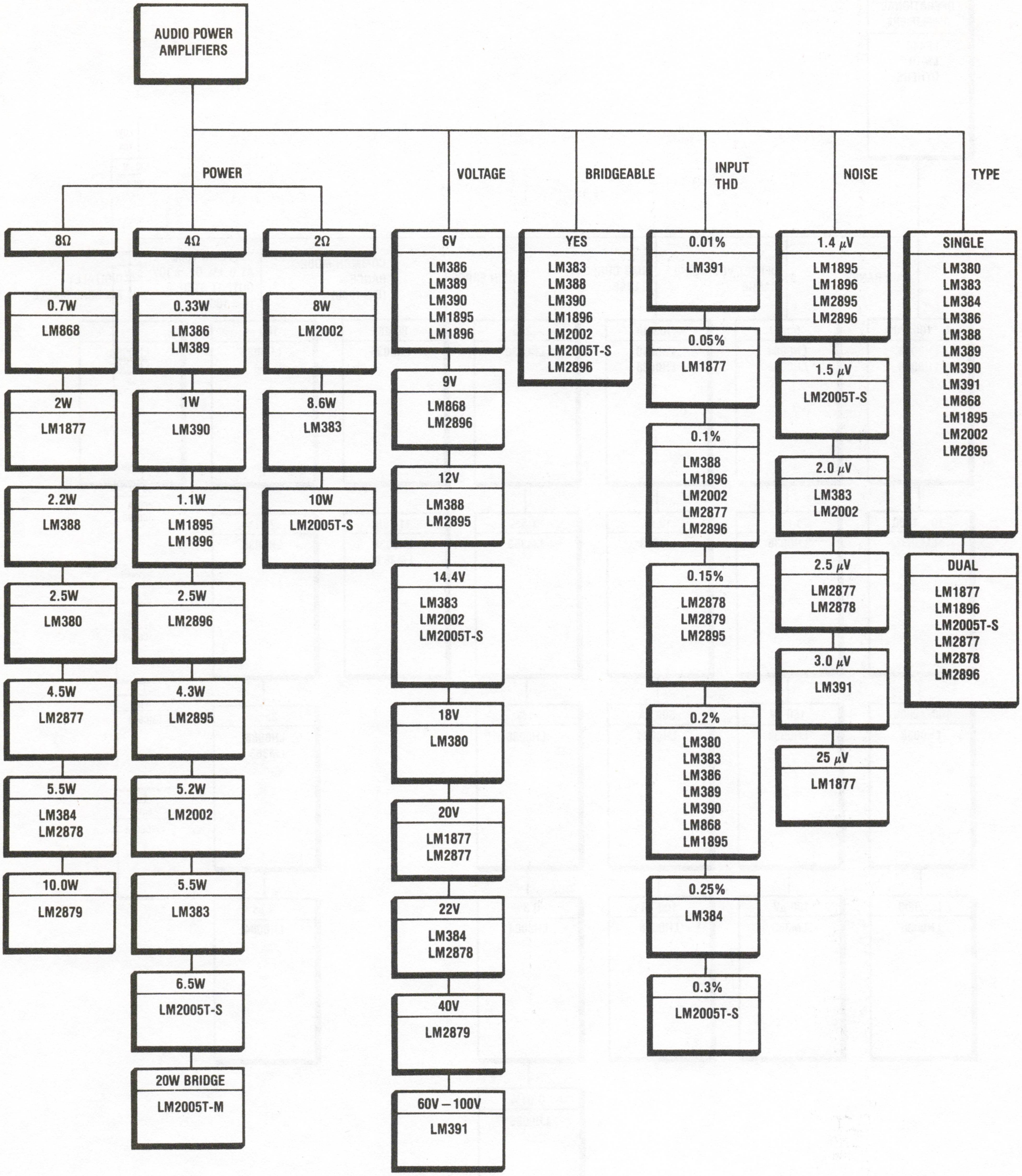
# Amplifier Selection Guide



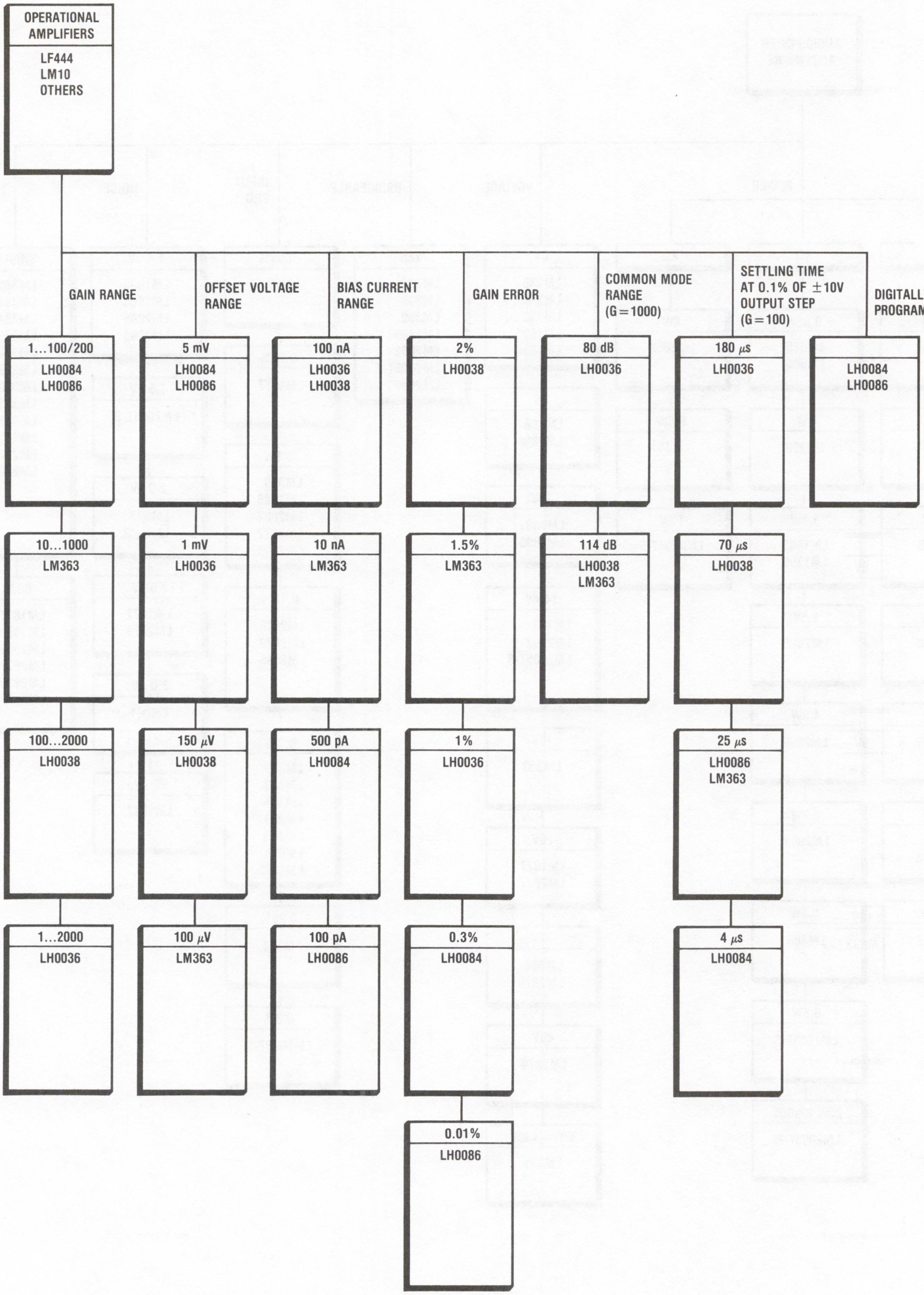
**GENERAL PURPOSE**
LF351
LM301
LM741
OTHERS

| HIGH SLEW RATE | LOW SUPPLY CURRENT | LOW NOISE | LOW DRIFT | HIGH POWER | HIGH SUPPLY VOLTAGE | HIGH INPUT IMPEDANCE | HIGH POWER BANDWIDTH | FOLLOWER | DUAL/QUAD | LOW $V_{OS}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| **10V/μs**<br>LF347<br>LF351<br>LF353<br>LF356<br>LF357<br>LF400<br>LF411<br>LF412<br>LM302 | **300 μA**<br>LM10<br>LM308<br>LM346 | **45 nV/√Hz**<br>LM10 | **10 μV/°C**<br>LF411A<br>LF421A<br>LF441A<br>LF442A<br>LF444A<br>LP324 | **100 mA**<br>LH0002<br>LH0033<br>LH4101<br>LH4001 | **+/−34V**<br>LM343<br>LM344 | **$4 \times 10^7 \Omega$**<br>LM308<br>LM312 | **200KHz**<br>LF356 | **250KHz**<br>LM302<br>LM310 | **DUAL**<br>LF353<br>LF412<br>LF442<br>LM358<br>LM359<br>LM833<br>LM1458<br>LM2904 | **500 μV**<br>LF400A<br>LF401<br>LF411<br>LM308A |
|  | **150 μA**<br>LF441<br>LF442<br>LF444<br>LP324 | **35 nV/√Hz**<br>LM301A<br>LM307<br>LM308 | **5 μV/°C**<br>LF355<br>LF356<br>LF357<br>LM308A | **200 mA**<br>LH0041 | **+/−45V**<br>LH0004 | **$10^9 \Omega$**<br>LM316 | **300KHz**<br>LH0101<br>LM675 | **25MHz**<br>LH4001 |  | **200 μV**<br>LF401A |
| **30V/μs**<br>LM310<br>LF400<br>LF401<br>LM359 | **10 μA**<br>LM4250 | **25 nV/√Hz**<br>LF347<br>LF411<br>LM747 | **2.5μV°/C**<br>LM607<br>LM627 | **250 mA**<br>LM13080 |  | **$10^{11} \Omega$**<br>LM11<br>LM607 | **400KHz**<br>LF357<br>LF400C | **30MHz**<br>LH0002<br>LH4001 | **QUAD**<br>LF347<br>LF444<br>LM324<br>LM346<br>LM348<br>LM349<br>LM2902<br>LM3403<br>LM3900<br>LP324<br>LP2902<br>LMC660<br>LM837 | **100 μV**<br>LM607<br>LM627 |
| **50V/μs**<br>LM318 |  | **20 nV/√Hz**<br>LF351<br>LF353<br>LF355 | **2 μV/°C**<br>LM10<br>LM11<br>LM725 | **0.5A**<br>LH0061 |  | **$10^{12} \Omega$**<br>LF351<br>LF353<br>LF355<br>LF356<br>LF357<br>LF400<br>LF411<br>LF412<br>LF441<br>LF442<br>LF444<br>LH0022<br>LH0032<br>LH0042<br>LH0052<br>LH4101<br>LM310<br>LH0062 | **1MHz**<br>LH0061 | **100MHz**<br>LH0033 |  | **50 μV**<br>LM607A<br>LMC669C |
| **200V/μs**<br>LH4101 |  | **12 nV/√Hz**<br>LF356<br>LF357 | **0.2 μV/°C**<br>LH0044<br>LM321A | **1A**<br>LH0021 |  |  | **1.5MHz**<br>LH0062<br>LM318 | **120MHz**<br>LH0063 |  | **25 μV**<br>LM607A<br>LM627A<br>LMC669B |
| **300V/μs**<br>LM6361<br>LM6364<br>LM6365 |  | **9 nV/√Hz**<br>LH0044 | **CONSTANT 25 μV**<br>LMC668<br>LMC669 | **2A**<br>LH0101 |  |  | **2.5MHz**<br>LM359 | **200MHz**<br>LH4002 |  | **10 μV**<br>LMC668 |
| **350V/μs**<br>LH0032 |  | **8 nV/√Hz**<br>LM321<br>LM725<br>LM607 |  | **4A**<br>LM675 |  |  | **15MHz**<br>LH0024<br>LH0032 |  |  | **5μV**<br>LMC668A |
| **400V/μs**<br>LH0024 |  | **4.5 nV/√Hz**<br>LM833<br>LM837 |  | **10A**<br>LM12 |  |  |  |  |  |  |
| **1000V/μs**<br>LH0033 |  |  |  |  |  |  |  |  |  |  |
| **1250V/μs**<br>LH4002 |  |  |  |  |  |  |  |  |  |  |
| **2000V/μs**<br>LH0063 |  |  |  |  |  |  |  |  |  |  |

# Audio Power Amplifier Selection Guide


AUDIO POWER AMPLIFIERS
POWER
8Ω
0.7W LM868
2W LM1877
2.2W LM388
2.5W LM380
4.5W LM2877
5.5W LM384 LM2878
10.0W LM2879
4Ω
0.33W LM386 LM389
1W LM390
1.1W LM1895 LM1896
2.5W LM2896
4.3W LM2895
5.2W LM2002
5.5W LM383
6.5W LM2005T-S
20W BRIDGE LM2005T-M
2Ω
8W LM2002
8.6W LM383
10W LM2005T-S
VOLTAGE
6V LM386 LM389 LM390 LM1895 LM1896
9V LM868 LM2896
12V LM388 LM2895
14.4V LM383 LM2002 LM2005T-S
18V LM380
20V LM1877 LM2877
22V LM384 LM2878
40V LM2879
60V – 100V LM391
BRIDGEABLE
YES LM383 LM388 LM390 LM1896 LM2002 LM2005T-S LM2896
INPUT THD
0.01% LM391
0.05% LM1877
0.1% LM388 LM1896 LM2002 LM2877 LM2896
0.15% LM2878 LM2879 LM2895
0.2% LM380 LM383 LM386 LM389 LM390 LM868 LM1895
0.25% LM384
0.3% LM2005T-S
NOISE
1.4 μV LM1895 LM1896 LM2895 LM2896
1.5 μV LM2005T-S
2.0 μV LM383 LM2002
2.5 μV LM2877 LM2878
3.0 μV LM391
25 μV LM1877
TYPE
SINGLE LM380 LM383 LM384 LM386 LM388 LM389 LM390 LM391 LM868 LM1895 LM2002 LM2895
DUAL LM1877 LM1896 LM2005T-S LM2877 LM2878 LM2896

# Instrumentation Amplifier Selection Guide

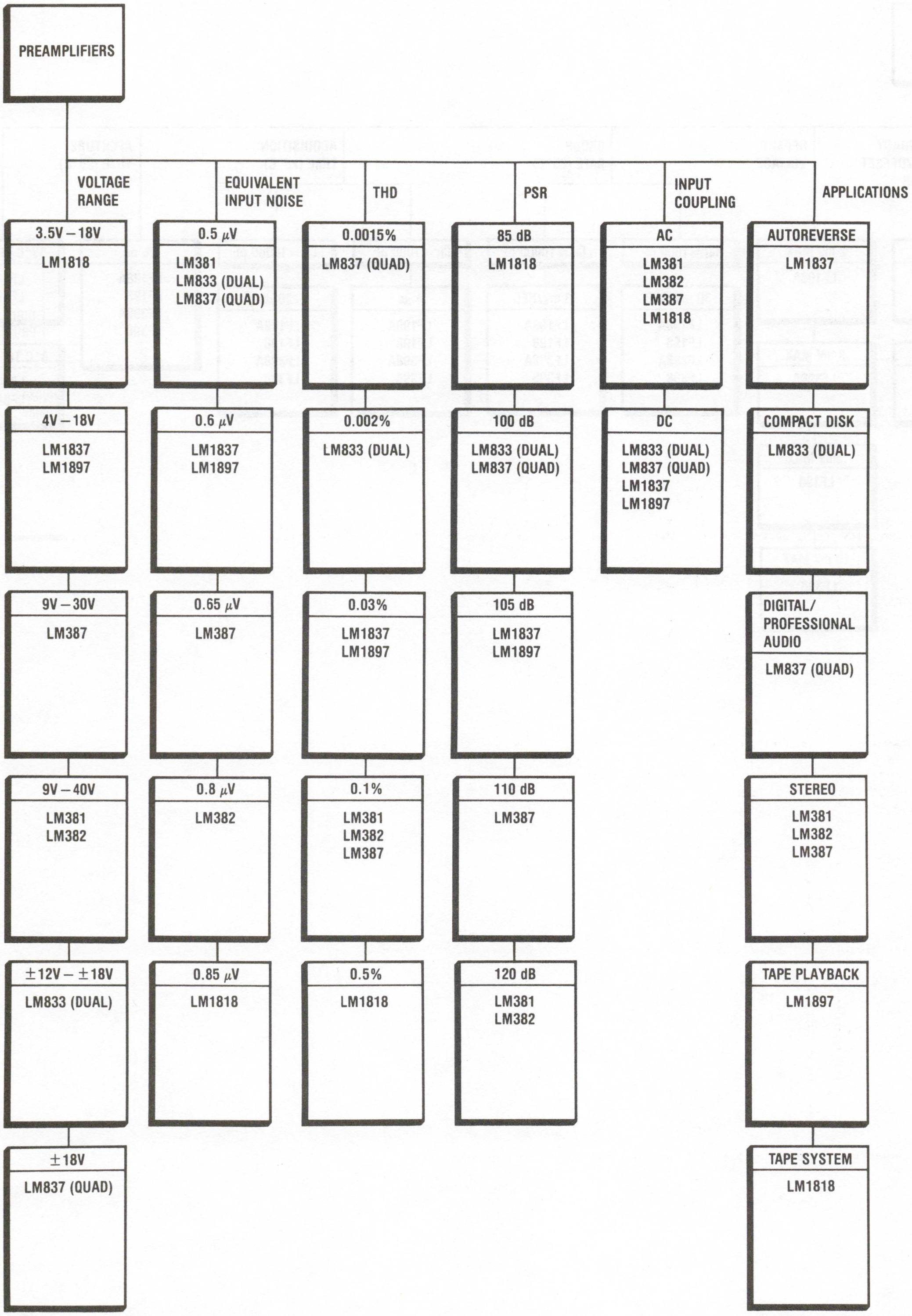


**OPERATIONAL AMPLIFIERS**

LF444
LM10
OTHERS

| GAIN RANGE | OFFSET VOLTAGE RANGE | BIAS CURRENT RANGE | GAIN ERROR | COMMON MODE RANGE (G = 1000) | SETTLING TIME AT 0.1% OF ±10V OUTPUT STEP (G = 100) | DIGITALLY PROGRAMMABLE |
|---|---|---|---|---|---|---|
| 1...100/200<br>LH0084<br>LH0086 | 5 mV<br>LH0084<br>LH0086 | 100 nA<br>LH0036<br>LH0038 | 2%<br>LH0038 | 80 dB<br>LH0036 | 180 µs<br>LH0036 | LH0084<br>LH0086 |
| 10...1000<br>LM363 | 1 mV<br>LH0036 | 10 nA<br>LM363 | 1.5%<br>LM363 | 114 dB<br>LH0038<br>LM363 | 70 µs<br>LH0038 | |
| 100...2000<br>LH0038 | 150 µV<br>LH0038 | 500 pA<br>LH0084 | 1%<br>LH0036 | | 25 µs<br>LH0086<br>LM363 | |
| 1...2000<br>LH0036 | 100 µV<br>LM363 | 100 pA<br>LH0086 | 0.3%<br>LH0084 | | 4 µs<br>LH0084 | |
| | | | 0.01%<br>LH0086 | | | |

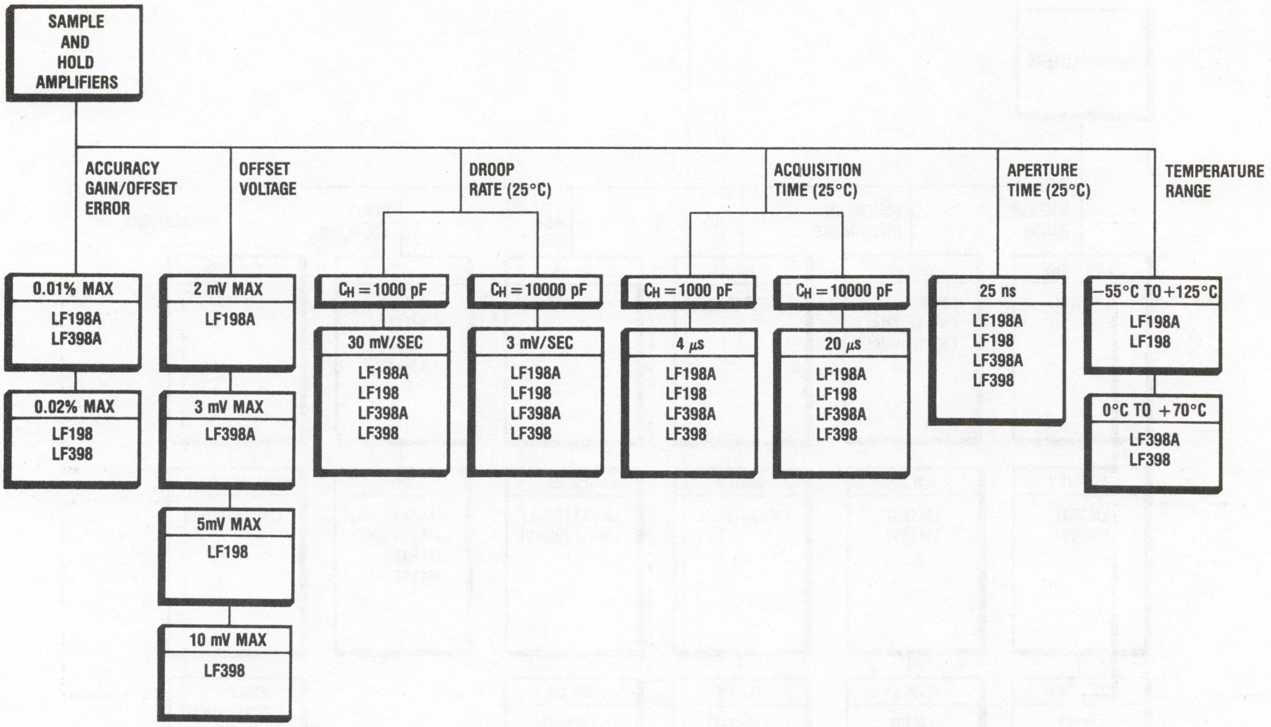
## Preamplifier Selection Guide



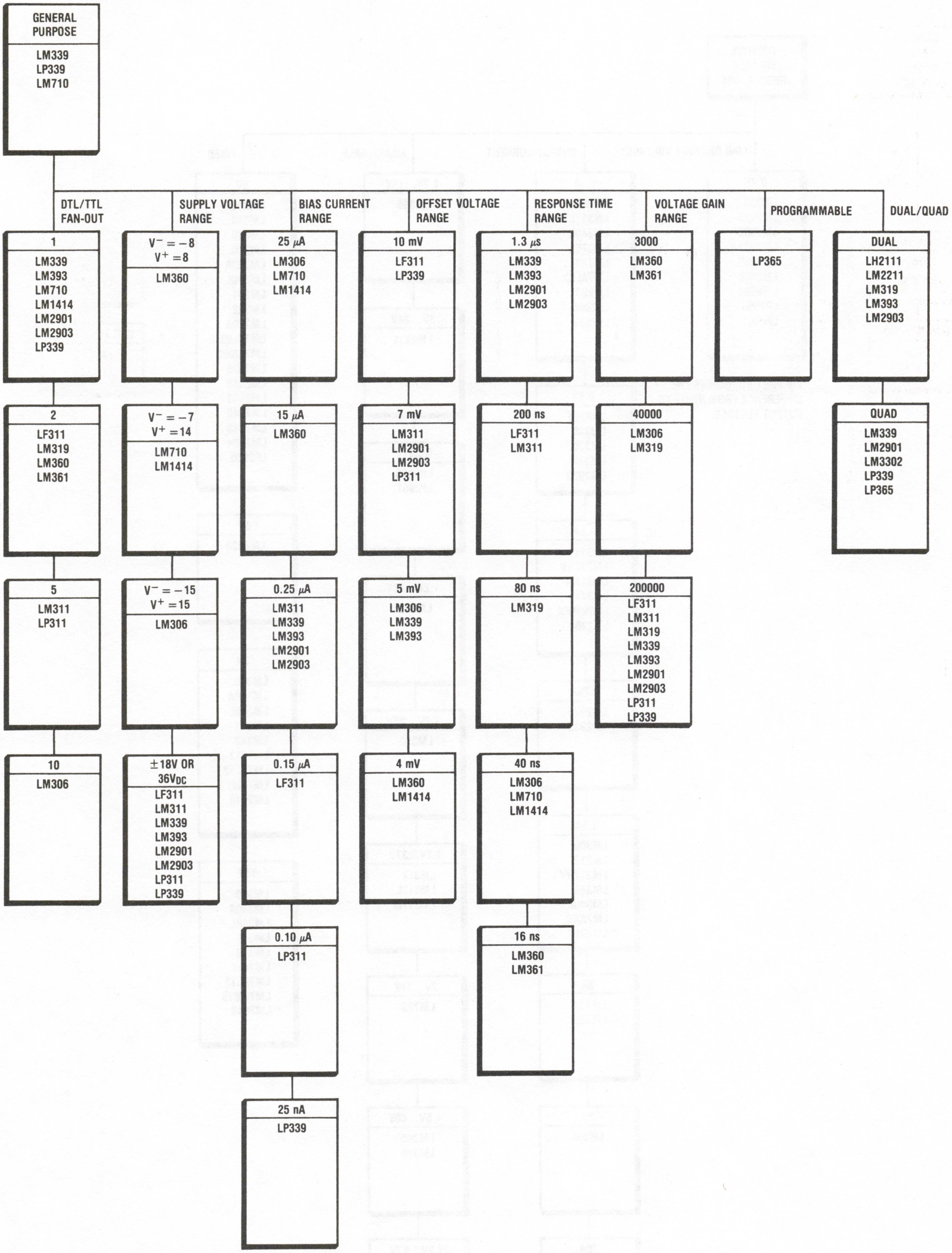
**PREAMPLIFIERS**

| VOLTAGE RANGE | EQUIVALENT INPUT NOISE | THD | PSR | INPUT COUPLING | APPLICATIONS |
|---|---|---|---|---|---|
| 3.5V – 18V<br>LM1818 | 0.5 µV<br>LM381<br>LM833 (DUAL)<br>LM837 (QUAD) | 0.0015%<br>LM837 (QUAD) | 85 dB<br>LM1818 | AC<br>LM381<br>LM382<br>LM387<br>LM1818 | AUTOREVERSE<br>LM1837 |
| 4V – 18V<br>LM1837<br>LM1897 | 0.6 µV<br>LM1837<br>LM1897 | 0.002%<br>LM833 (DUAL) | 100 dB<br>LM833 (DUAL)<br>LM837 (QUAD) | DC<br>LM833 (DUAL)<br>LM837 (QUAD)<br>LM1837<br>LM1897 | COMPACT DISK<br>LM833 (DUAL) |
| 9V – 30V<br>LM387 | 0.65 µV<br>LM387 | 0.03%<br>LM1837<br>LM1897 | 105 dB<br>LM1837<br>LM1897 | | DIGITAL/ PROFESSIONAL AUDIO<br>LM837 (QUAD) |
| 9V – 40V<br>LM381<br>LM382 | 0.8 µV<br>LM382 | 0.1%<br>LM381<br>LM382<br>LM387 | 110 dB<br>LM387 | | STEREO<br>LM381<br>LM382<br>LM387 |
| ±12V – ±18V<br>LM833 (DUAL) | 0.85 µV<br>LM1818 | 0.5%<br>LM1818 | 120 dB<br>LM381<br>LM382 | | TAPE PLAYBACK<br>LM1897 |
| ±18V<br>LM837 (QUAD) | | | | | TAPE SYSTEM<br>LM1818 |

# Sample and Hold Amplifier Selection Guide

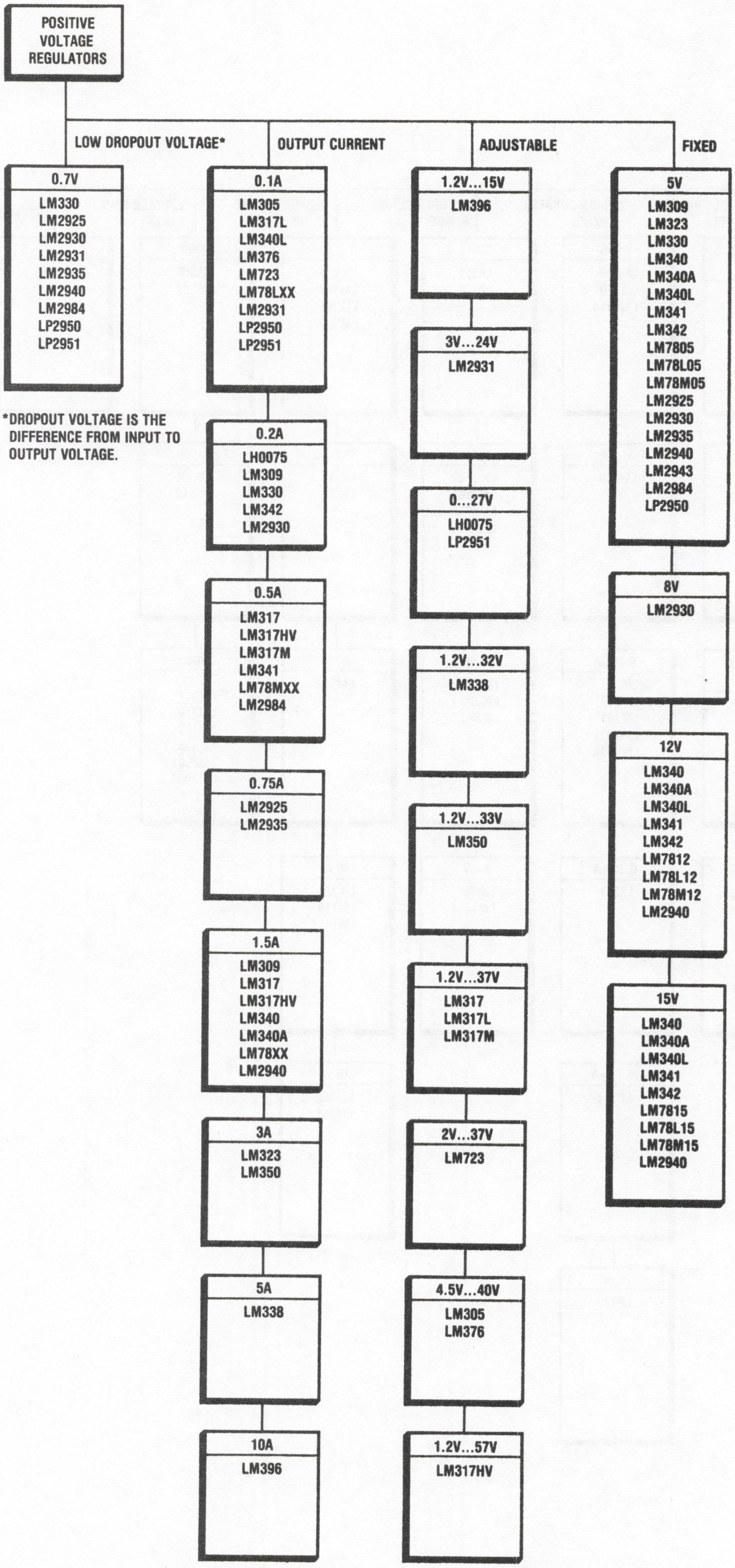

SAMPLE AND HOLD AMPLIFIERS
ACCURACY GAIN/OFFSET ERROR
0.01% MAX
LF198A
LF398A
0.02% MAX
LF198
LF398
OFFSET VOLTAGE
2 mV MAX
LF198A
3 mV MAX
LF398A
5mV MAX
LF198
10 mV MAX
LF398
DROOP RATE (25°C)
CH = 1000 pF
30 mV/SEC
LF198A
LF198
LF398A
LF398
CH = 10000 pF
3 mV/SEC
LF198A
LF198
LF398A
LF398
ACQUISITION TIME (25°C)
CH = 1000 pF
4 μs
LF198A
LF198
LF398A
LF398
CH = 10000 pF
20 μs
LF198A
LF198
LF398A
LF398
APERTURE TIME (25°C)
25 ns
LF198A
LF198
LF398A
LF398
TEMPERATURE RANGE
−55°C TO +125°C
LF198A
LF198
0°C TO +70°C
LF398A
LF398

# Comparator Selection Guide



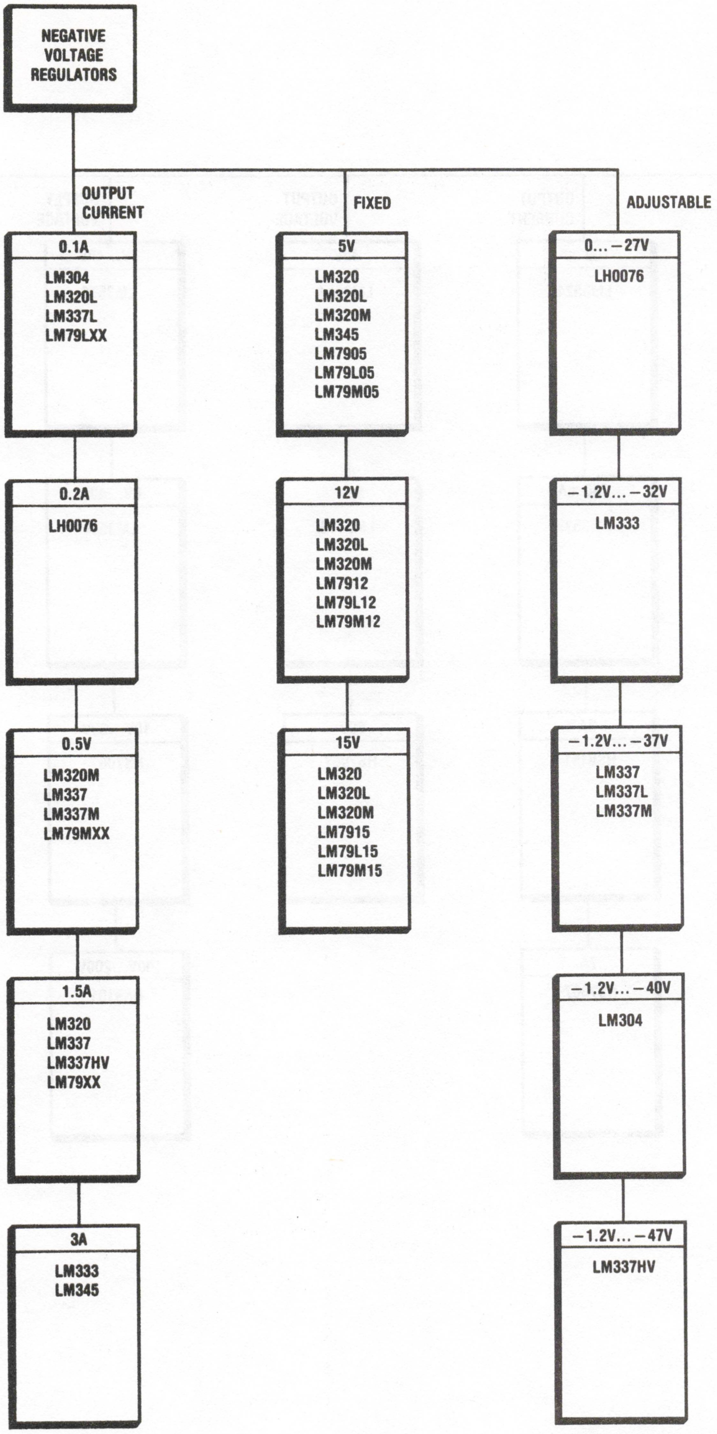
- **GENERAL PURPOSE**: LM339, LP339, LM710
- **DTL/TTL FAN-OUT**
  - 1: LM339, LM393, LM710, LM1414, LM2901, LM2903, LP339
  - 2: LF311, LM319, LM360, LM361
  - 5: LM311, LP311
  - 10: LM306
- **SUPPLY VOLTAGE RANGE**
  - $V^- = -8$, $V^+ = 8$: LM360
  - $V^- = -7$, $V^+ = 14$: LM710, LM1414
  - $V^- = -15$, $V^+ = 15$: LM306
  - ±18V OR $36V_{DC}$: LF311, LM311, LM339, LM393, LM2901, LM2903, LP311, LP339
- **BIAS CURRENT RANGE**
  - 25 μA: LM306, LM710, LM1414
  - 15 μA: LM360
  - 0.25 μA: LM311, LM339, LM393, LM2901, LM2903
  - 0.15 μA: LF311
  - 0.10 μA: LP311
  - 25 nA: LP339
- **OFFSET VOLTAGE RANGE**
  - 10 mV: LF311, LP339
  - 7 mV: LM311, LM2901, LM2903, LP311
  - 5 mV: LM306, LM339, LM393
  - 4 mV: LM360, LM1414
- **RESPONSE TIME RANGE**
  - 1.3 μs: LM339, LM393, LM2901, LM2903
  - 200 ns: LF311, LM311
  - 80 ns: LM319
  - 40 ns: LM306, LM710, LM1414
  - 16 ns: LM360, LM361
- **VOLTAGE GAIN RANGE**
  - 3000: LM360, LM361
  - 40000: LM306, LM319
  - 200000: LF311, LM311, LM319, LM339, LM393, LM2901, LM2903, LP311, LP339
- **PROGRAMMABLE**: LP365
- **DUAL/QUAD**
  - DUAL: LH2111, LM2211, LM319, LM393, LM2903
  - QUAD: LM339, LM2901, LM3302, LP339, LP365

# Positive Voltage Regulator Selection Guide

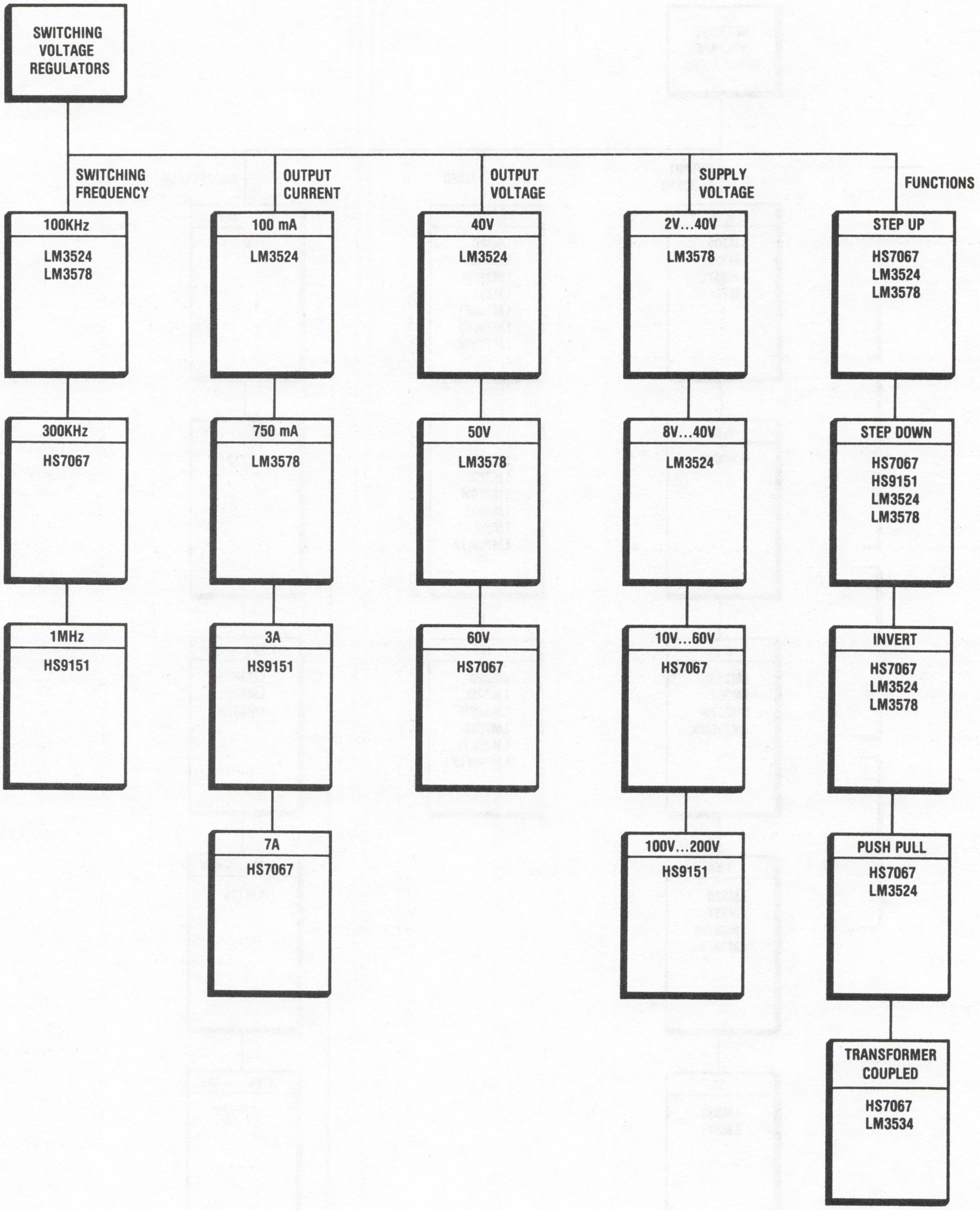

POSITIVE VOLTAGE REGULATORS
LOW DROPOUT VOLTAGE*
OUTPUT CURRENT
ADJUSTABLE
FIXED
0.7V
LM330
LM2925
LM2930
LM2931
LM2935
LM2940
LM2984
LP2950
LP2951
0.1A
LM305
LM317L
LM340L
LM376
LM723
LM78LXX
LM2931
LP2950
LP2951
0.2A
LH0075
LM309
LM330
LM342
LM2930
0.5A
LM317
LM317HV
LM317M
LM341
LM78MXX
LM2984
0.75A
LM2925
LM2935
1.5A
LM309
LM317
LM317HV
LM340
LM340A
LM78XX
LM2940
3A
LM323
LM350
5A
LM338
10A
LM396
1.2V...15V
LM396
3V...24V
LM2931
0...27V
LH0075
LP2951
1.2V...32V
LM338
1.2V...33V
LM350
1.2V...37V
LM317
LM317L
LM317M
2V...37V
LM723
4.5V...40V
LM305
LM376
1.2V...57V
LM317HV
5V
LM309
LM323
LM330
LM340
LM340A
LM340L
LM341
LM342
LM7805
LM78L05
LM78M05
LM2925
LM2930
LM2935
LM2940
LM2943
LM2984
LP2950
8V
LM2930
12V
LM340
LM340A
LM340L
LM341
LM342
LM7812
LM78L12
LM78M12
LM2940
15V
LM340
LM340A
LM340L
LM341
LM342
LM7815
LM78L15
LM78M15
LM2940

*DROPOUT VOLTAGE IS THE DIFFERENCE FROM INPUT TO OUTPUT VOLTAGE.

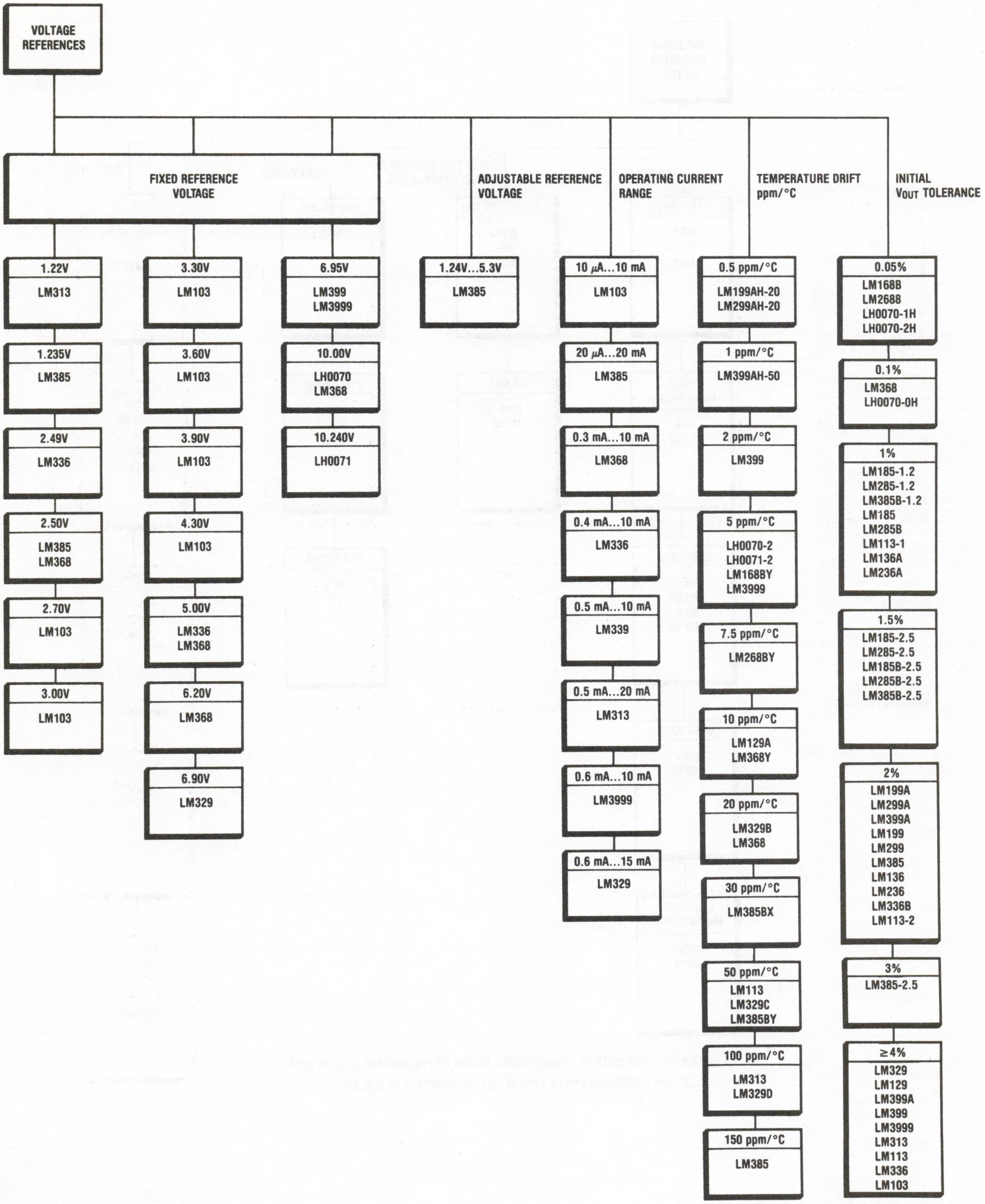
## Negative Voltage Regulator Selection Guide


NEGATIVE VOLTAGE REGULATORS
OUTPUT CURRENT
0.1A
LM304
LM320L
LM337L
LM79LXX
0.2A
LH0076
0.5V
LM320M
LM337
LM337M
LM79MXX
1.5A
LM320
LM337
LM337HV
LM79XX
3A
LM333
LM345
FIXED
5V
LM320
LM320L
LM320M
LM345
LM7905
LM79L05
LM79M05
12V
LM320
LM320L
LM320M
LM7912
LM79L12
LM79M12
15V
LM320
LM320L
LM320M
LM7915
LM79L15
LM79M15
ADJUSTABLE
0... −27V
LH0076
−1.2V... −32V
LM333
−1.2V... −37V
LM337
LM337L
LM337M
−1.2V... −40V
LM304
−1.2V... −47V
LM337HV

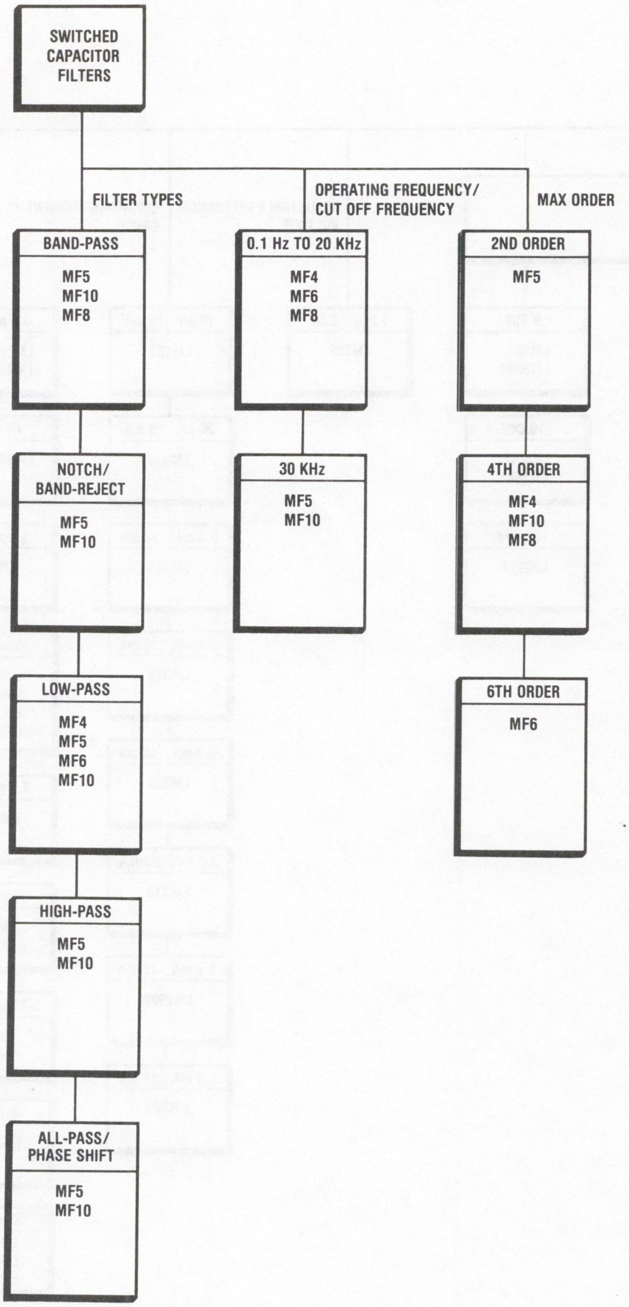
## Switching Voltage Regulator Selection Guide


SWITCHING VOLTAGE REGULATORS
SWITCHING FREQUENCY
100KHz
LM3524
LM3578
300KHz
HS7067
1MHz
HS9151
OUTPUT CURRENT
100 mA
LM3524
750 mA
LM3578
3A
HS9151
7A
HS7067
OUTPUT VOLTAGE
40V
LM3524
50V
LM3578
60V
HS7067
SUPPLY VOLTAGE
2V...40V
LM3578
8V...40V
LM3524
10V...60V
HS7067
100V...200V
HS9151
FUNCTIONS
STEP UP
HS7067
LM3524
LM3578
STEP DOWN
HS7067
HS9151
LM3524
LM3578
INVERT
HS7067
LM3524
LM3578
PUSH PULL
HS7067
LM3524
TRANSFORMER COUPLED
HS7067
LM3534

# Voltage Reference Selection Guide


VOLTAGE REFERENCES
FIXED REFERENCE VOLTAGE
ADJUSTABLE REFERENCE VOLTAGE
OPERATING CURRENT RANGE
TEMPERATURE DRIFT ppm/°C
INITIAL VOUT TOLERANCE
1.22V
LM313
1.235V
LM385
2.49V
LM336
2.50V
LM385
LM368
2.70V
LM103
3.00V
LM103
3.30V
LM103
3.60V
LM103
3.90V
LM103
4.30V
LM103
5.00V
LM336
LM368
6.20V
LM368
6.90V
LM329
6.95V
LM399
LM3999
10.00V
LH0070
LM368
10.240V
LH0071
1.24V…5.3V
LM385
10 µA…10 mA
LM103
20 µA…20 mA
LM385
0.3 mA…10 mA
LM368
0.4 mA…10 mA
LM336
0.5 mA…10 mA
LM339
0.5 mA…20 mA
LM313
0.6 mA…10 mA
LM3999
0.6 mA…15 mA
LM329
0.5 ppm/°C
LM199AH-20
LM299AH-20
1 ppm/°C
LM399AH-50
2 ppm/°C
LM399
5 ppm/°C
LH0070-2
LH0071-2
LM168BY
LM3999
7.5 ppm/°C
LM268BY
10 ppm/°C
LM129A
LM368Y
20 ppm/°C
LM329B
LM368
30 ppm/°C
LM385BX
50 ppm/°C
LM113
LM329C
LM385BY
100 ppm/°C
LM313
LM329D
150 ppm/°C
LM385
0.05%
LM168B
LM2688
LH0070-1H
LH0070-2H
0.1%
LM368
LH0070-0H
1%
LM185-1.2
LM285-1.2
LM385B-1.2
LM185
LM285B
LM113-1
LM136A
LM236A
1.5%
LM185-2.5
LM285-2.5
LM185B-2.5
LM285B-2.5
LM385B-2.5
2%
LM199A
LM299A
LM399A
LM199
LM299
LM385
LM136
LM236
LM336B
LM113-2
3%
LM385-2.5
≥4%
LM329
LM129
LM399A
LM399
LM3999
LM313
LM113
LM336
LM103

# Switched Capacitor Filter Selection Guide


SWITCHED CAPACITOR FILTERS
FILTER TYPES
OPERATING FREQUENCY/ CUT OFF FREQUENCY
MAX ORDER
BAND-PASS
MF5
MF10
MF8
NOTCH/ BAND-REJECT
MF5
MF10
LOW-PASS
MF4
MF5
MF6
MF10
HIGH-PASS
MF5
MF10
ALL-PASS/ PHASE SHIFT
MF5
MF10
0.1 Hz TO 20 KHz
MF4
MF6
MF8
30 KHz
MF5
MF10
2ND ORDER
MF5
4TH ORDER
MF4
MF10
MF8
6TH ORDER
MF6

THE MF10 DEVICE CONSISTS OF 2 INDEPENDENT ACTIVE FILTER BUILDING BLOCKS (MF5).
ALL DEVICES ARE CASCADABLE WITH TYPICAL $f_{CLK}/f_0$ ACCURACY OF ±0.3%

# Analog-to-Digital Converter Selection Guide

| Part Number | Resolution (Bits) | Absolute Accuracy (Max) | Conversion Time | Input Voltage Range (V) | Output Logic Levels | Supplies (V) | Comments |
|---|---|---|---|---|---|---|---|
| ADC0800 | 8 | ± 2 LSB | 50 μs | ± 5 | TTL, TRI-STATE | + 5, − 12 | Ratiometric Operation |
| ADC0801 | 8 | ± 1/4 LSB | 110 μs | 5 | TTL, TRI-STATE | + 5 | Differential Input |
| ADC0802 | 8 | ± 1/2 LSB | 110 μs | 5 | TTL, TRI-STATE | + 5 | Differential Input |
| ADC0803 | 8 | ± 1/2 LSB | 110 μs | 5 | TTL, TRI-STATE | + 5 | Differential Input |
| ADC0804 | 8 | ± 1 LSB | 110 μs | 5 | TTL, TRI-STATE | + 5 | Differential Input |
| ADC0805 | 8 | ± 1/2 LSB | 110 μs | 5 | TTL, TRI-STATE | + 5 | Ratiometric Operation |
| ADC0808 | 8 | ± 1/2 LSB | 100 μs | 5 | TTL, TRI-STATE | + 5 | 8-Channel MUX |
| ADC0809 | 8 | ± 1 LSB | 100 μs | 5 | TTL, TRI-STATE | + 5 | 8-Channel MUX |
| ADC0811B | 8 | ± 1/2 LSB | 32 μs | 5 | TTL | + 5 | 11-Channel Serial I/O |
| ADC0811C | 8 | ± 1 LSB | 32 μs | 5 | TTL | + 5 | 11-Channel Serial I/O |
| ADC0816 | 8 | ± 1/2 LSB | 100 μs | 5 | TTL, TRI-STATE | + 5 | 16-Channel MUX |
| ADC0817 | 8 | ± 1 LSB | 100 μs | 5 | TTL, TRI-STATE | + 5 | 16-Channel MUX |
| ADC0819B | 8 | ± 1/2 LSB | 16 μs | 5 | TTL | + 5 | 19-Channel Serial I/O |
| ADC0819C | 8 | ± 1 LSB | 16 μs | 5 | TTL | + 5 | 19-Channel Serial I/O |
| ADC0820B | 8 | ± 1/2 LSB | 1.2 μs | 5 | TTL, TRI-STATE | + 5 | Built-in Track and Hold Function |
| ADC0820C | 8 | ± 1 LSB | 1.2 μs | 5 | TTL, TRI-STATE | + 5 | Built-in Track and Hold Function |
| ADC0829B | 8 | ± 1/2 LSB | 100 μs | 5 | TTL, TRI-STATE | + 5 | Additional Digital Input Capability |
| ADC0829C | 8 | ± 1 LSB | 100 μs | 5 | TTL, TRI-STATE | + 5 | Additional Digital Input Capability |
| ADC0831B | 8 | ± 1/2 LSB | 32 μs | 5 | TTL | + 5 | Serial I/O |
| ADC0831C | 8 | ± 1 LSB | 32 μs | 5 | TTL | + 5 | Serial I/O |
| ADC0832B | 8 | ± 1/2 LSB | 32 μs | 5 | TTL | + 5 | 2-Channel Serial I/O |
| ADC0832C | 8 | ± 1 LSB | 32 μs | 5 | TTL | + 5 | 2-Channel Serial I/O |
| ADC0833B | 8 | ± 1/2 LSB | 32 μs | 5 | TTL | + 5 to + 9 | 4-Channel Serial I/O |
| ADC0833C | 8 | ± 1 LSB | 32 μs | 5 | TTL | + 5 to + 9 | 4-Channel Serial I/O |
| ADC0834B | 8 | ± 1/2 LSB | 32 μs | 5 | TTL | + 5 to + 9 | 4-Channel Serial I/O |
| ADC0834C | 8 | ± 1 LSB | 32 μs | 5 | TTL | + 5 to + 9 | 4-Channel Serial I/O |
| ADC0838B | 8 | ± 1/2 LSB | 32 μs | 5 | TTL | + 5 to + 9 | 8-Channel Serial I/O |
| ADC0838C | 8 | ± 1 LSB | 32 μs | 5 | TTL | + 5 to + 9 | 8-Channel Serial I/O |
| ADC0844B | 8 | ± 1/2 LSB | 40 μs | 5 | TTL, TRI-STATE | + 5 | 4-Channel MUX, Internal Clock |
| ADC0844C | 8 | ± 1 LSB | 40 μs | 5 | TTL, TRI-STATE | + 5 | 4-Channel MUX, Internal Clock |
| ADC0848B | 8 | ± 1/2 LSB | 40 μs | 5 | TTL, TRI-STATE | + 5 | 8-Channel MUX, Internal Clock |
| ADC0848C | 8 | ± 1 LSB | 40 μs | 5 | TTL, TRI-STATE | + 5 | 8-Channel MUX, Internal Clock |
| ADC1001C | 10 | ± 1 LSB | 200 μs | 5 | TTL, TRI-STATE | + 5 | 8-Bit Bus Compatible Differential Input |
| ADC1005B | 10 | ± 1/2 LSB | 200 μs | 5 | TTL, TRI-STATE | + 5 | 8-Bit Bus Compatible Differential Input |
| ADC1005C | 10 | ± 1 LSB | 50 μs | 5 | TTL, TRI-STATE | + 5 | 8-Bit Bus Compatible Differential Input |

## Analog-to-Digital Converter Selection Guide

| Part Number | Resolution (Bits) | Absolute Accuracy (Max) | Conversion Time | Input Voltage Range (V) | Output Logic Levels | Supplies (V) | Comments |
|---|---|---|---|---|---|---|---|
| ADC1021B | 10 | ± 1/2 LSB | 200 µs | 5 | TTL, TRI-STATE | + 5 | Differential Input |
| ADC1021C | 10 | ± 1 LSB | 200 µs | 5 | TTL, TRI-STATE | + 5 | Differential Input |
| ADC1025B | 10 | ± 1/2 LSB | 50 µs | 5 | TTL, TRI-STATE | + 5 | Differential Input |
| ADC1025C | 10 | ± 1 LSB | 50 µs | 5 | TTL, TRI-STATE | + 5 | Differential Input |
| ADC1205B | 12 | ± 1/2 LSB | 100 µs | ± 5 | TTL, TRI-STATE | + 5 | 8-Bit Bus Compatible Differential Input |
| ADC1205C | 12 | ± 1 LSB | 100 µs | ± 5 | TTL, TRI-STATE | + 5 | 8-Bit Bus Compatible Differential Input |
| ADC1210 | 12 | ± 3/4 LSB | 200 µs | 10.2 | CMOS | + 5 to ± 15 | Bipolar Input |
| ADC1211 | 12 | ± 2 LSB | 200 µs | 10.2 | CMOS | + 5 to ± 15 | Bipolar Input |
| ADC1225B | 12 | ± 1/2 LSB | 100 µs | ± 5 | TTL, TRI-STATE | + 5 | 16-Bit Bus Compatible Differential Input |
| ADC1225C | 12 | ± 1 LSB | 100 µs | ± 5 | TTL, TRI-STATE | + 5 | 16-Bit Bus Compatible Differential Input |
| ADC3511 | 3-1/2 Digit | 0.05% | 200 ms | 2 | TTL, TRI-STATE | + 5 | µP Compatible |
| ADC3711 | 3-3/4 Digit | 0.05% | 400 ms | 2 | TTL, TRI-STATE | + 5 | µP Compatible |
| LM131 | V-F | 0.01% | N/A | $V_{CC} - 2$ | Open Collector | + 5 to + 40 | Voltage-to-Frequency Converter 100kHz Max |
| **DIGITAL VOLT METER** | | | | | | | |
| ADC3501 | 3-1/2 Digit | 0.05% | 200 ms | 2 | 7-Segment LED Drive | + 5 | 3-1/2 Digit LED DVM |
| ADD3701 | 3-3/4 Digit | 0.05% | 400 ms | 2 | 7-Segment LED Drive | + 5 | 3-3/4 Digit LED DVM |

## Digital-to-Analog Converter Selection Guide

| Part Number | Resolution (Bits) | Linearity at 25°C (% Max) | Internal Reference | Settling Time ( + 1/2 LSB) | Supplies (V) | Comments |
|---|---|---|---|---|---|---|
| ADC0852 | 8 | 0.19 | | 4 μs | 5 | DAC, Comparator, Serial Input |
| ADC0854 | 8 | 0.39 | | 4 μs | 5 | DAC, Comparator, Serial Input |
| DAC0800 | 8 | 0.19 | | 100 ns | ± 5 to ± 15 | High-Speed Multiplying |
| DAC0801 | 8 | 0.39 | | 100 ns | ± 5 to ± 15 | High-Speed Multiplying |
| DAC0802 | 8 | 0.1 | | 100 ns | ± 5 to ± 15 | High-Speed Multiplying |
| DAC0806 | 8 | 0.78 | | 150 ns | ± 5 to ± 15 | Multiplying |
| DAC0807 | 8 | 0.39 | | 150 ns | ± 5 to ± 15 | Multiplying |
| DAC0808 | 8 | 0.19 | | 150 ns | ± 5 to ± 15 | Multiplying |
| DAC0830 | 8 | 0.05 | | 1 μs | 5 to 15 | μP Compatible, 4-Quadrant Multiplying |
| DAC0831 | 8 | 0.10 | | 1 μs | 5 to 15 | μP Compatible, 4-Quadrant Multiplying |
| DAC0832 | 8 | 0.20 | | 1 μs | 5 to 15 | μP Compatible, 4-Quadrant Multiplying |
| DAC1000 | 10 | 0.05 | | 500 ns | 5 to 15 | μP Compatible, Double Buffered |
| DAC1001 | 10 | 0.1 | | 500 ns | 5 to 15 | μP Compatible, Double Buffered |
| DAC1002 | 10 | 0.2 | | 500 ns | 5 to 15 | μP Compatible, Double Buffered |
| DAC1006 | 10 | 0.05 | | 500 ns | 5 to 15 | μP Compatible, Double Buffered |
| DAC1007 | 10 | 0.1 | | 500 ns | 5 to 15 | μP Compatible, Double Buffered |
| DAC1008 | 10 | 0.2 | | 500 ns | 5 to 15 | μP Compatible, Double Buffered |
| DAC1020 | 10 | 0.05 | | 500 ns | 5 to 15 | 4-Quadrant Multiplying |
| DAC1021 | 10 | 0.1 | | 500 ns | 5 to 15 | 4-Quadrant Multiplying |
| DAC1022 | 10 | 0.2 | | 500 ns | 5 to 15 | 4-Quadrant Multiplying |
| DAC1208 | 12 | 0.012 | | 1 μs | 5 to 15 | μP Compatible, 4-Quadrant Multiplying |
| DAC1209 | 12 | 0.024 | | 1 μs | 5 to 15 | μP Compatible, 4-Quadrant Multiplying |
| DAC1210 | 12 | 0.05 | | 1 μs | 5 to 15 | μP Compatible, 4-Quadrant Multiplying |
| DAC1218 | 12 | 0.012 | | 1 μs | 5 to 15 | 4-Quadrant Multiplying |
| DAC1219 | 12 | 0.024 | | 1 μs | 5 to 15 | 4-Quadrant Multiplying |
| DAC1220 | 12 | 0.05 | | 500 ns | 5 to 15 | 4-Quadrant Multiplying |
| DAC1221 | 12 | 0.1 | | 500 ns | 5 to 15 | 4-Quadrant Multiplying |
| DAC1222 | 12 | 0.2 | | 500 ns | 5 to 15 | 4-Quadrant Multiplying |
| DAC1230 | 12 | 0.012 | | 1 μs | 5 to 15 | μP Compatible, 4-Quadrant Multiplying |
| DAC1231 | 12 | 0.024 | | 1 μs | 5 to 15 | μP Compatible, 4-Quadrant Multiplying |
| DAC1232 | 12 | 0.05 | | 1 μs | 5 to 15 | μP Compatible, 4-Quadrant Multiplying |
| DAC1265 | 12 | 0.012 | Yes | 200 ns | ± 15 | High-Speed |
| DAC1266 | 12 | 0.012 | | 200 ns | ± 12 to ± 15 | High-Speed |
| DAC1655 | 16 | 0.012 | | 20 μs | 5 to 15 | High-Speed |

## Analog Switch/Multiplexer Selection Guide

| Part Number | Function | Logic Input | $V_S$ Typ (V) | $t_{ON}$ Typ (ns) | $R_{ON}$ (Ω) |
|---|---|---|---|---|---|
| AH5011 | Quad SPST | TTL, CMOS | | 150 | 100 |
| AH5012 | | TTL, CMOS | | 150 | 150 |
| CD4016 | | CMOS | ± 7.5 | 20 | 850 |
| CD4066 | | CMOS | ± 7.5 | 50 | 280 |
| LF11201 | | TTL | ± 15 | 90 | 200 |
| LF11202 | | TTL | ± 15 | 90 | 200 |
| LF11331 | | TTL | ± 15 | 90 | 200 |
| LF11332 | | TTL | ± 15 | 90 | 200 |
| LF11333 | | TTL | ± 15 | 90 | 200 |
| LF13201 | | TTL | ± 15 | 90 | 250 |
| LF13202 | | TTL | ± 15 | 90 | 250 |
| LF13331 | | TTL | ± 15 | 90 | 250 |
| LF13332 | | TTL | ± 15 | 90 | 250 |
| LF13333 | | TTL | ± 15 | 90 | 250 |
| AH5020 | Dual SPDT | TTL, CMOS | | 150 | |
| CD4053 | Triple SPDT | CMOS | ± 7.5 | 150 | 280 |
| AH5009 | 4-Channel | TTL, CMOS | | 150 | 100 |
| AH5010 | | TTL, CMOS | | 150 | 150 |
| CD4052 | 4-Channel Differential | CMOS | ± 7.5 | 150 | 280 |
| CD4529B | | CMOS | ± 7.5 | 50 | 270 |
| LF11509 | | TTL | ± 15 | 1 μs | 350 |
| LF13509 | | TTL, CMOS | ± 18 | 1.6 μs | 350 |
| CD4051 | 8-Channel | CMOS | ± 7.5 | 150 | 280 |
| CD4529B | | CMOS | ± 7.5 | 50 | 270 |
| LF13508 | | TTL, CMOS | ± 18 | 1.6 μs | 350 |

## AM/FM Block and Stereo Decoder Selection Guide

The series of AM/FM circuits manufactured by National Semiconductor covers both low cost AM/FM combined circuits and highest quality single system circuits for AM and FM, which support automatic station search and PLL-tuned systems. Stereo decoders are available for both FM and AM-stereo.

### Combined Circuits

| | |
|---|---|
| LM1866 | AM/FM Radio System (Low Voltage) |
| LM1868 | AM/FM Radio with Audio Power Amplifier |

### AM Circuits

| | |
|---|---|
| LM1863 | AM Radio System for μP Tuned Radios |
| LM3820 | AM Radio System |

### FM Circuits

| | |
|---|---|
| LM1865 | FM-IF System for μP Tuned Radios |
| LM1965 | FM-IF System for Manually Tuned Radios |
| LM2065 | FM-IF System with Forward AGC |
| LM3089 | FM Receiver System |
| LM3189 | FM Receiver IF System |
| LM3361A | Low Voltage, Low Power Narrow Band FM-IF System |

### FM Stereo Decoders

| | |
|---|---|
| LM1800 | PLL-FM Stereo Demodulator |
| LM1870 | PLL-FM Stereo Demodulator with Blend |
| LM4500A | PLL-FM Stereo Demodulator with Blend |

## Audio Switches and Noise Reduction Systems Selection Guide

National Semiconductor produces two special circuits for electronic switching of audio sources. One is for direct control and the other has latches for $\mu$P control. Three different noise reduction systems are supported. Currently in production are Dolby B™ and Dolby C™ circuits and the DNR™ universal noise reduction system invented by National Semiconductor.

### Audio Switches

| | |
|---|---|
| LM1037 | Dual Four-Channel Analog Switch |
| LM1038 | Dual Four-Channel Analog Switch |

### Dolby™ Circuits

| | |
|---|---|
| LM1112 | Single Channel Dolby B |
| LM1122 | Single Channel Dolby C |
| LM1123 | Single Channel Dolby C |
| LM1131 | Dual Channel Dolby B |
| LM1141 | Single Chip Dolby C |

### DNR Circuits

| | |
|---|---|
| LM832 | Dual Channel DNR (Low Voltage) |
| LM1894 | Dual Channel DNR |

### Tape Systems

| | |
|---|---|
| LM834 | HiFi Tape System |
| LM1818 | Electronically Switched Tape System |
| LM1837 | Autoreverse Tape Head Preamplifier |
| LM1897 | Stereo Tape Head Preamplifier |

## Audio Controls Selection Guide

| Part Number | Application Portable | Home | Auto | Package | Voltage Range | Control Range | S/N | THD | Separation | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| LM1035 | • | • | • | N20 | 8V–18V | 80 dB Volume<br>± 15 dB Tone | 80 dB | 0.05 % | 75 dB | Dual channel with DC tone, volume, balance controls. 1 VRMS input loudness. |
| LM1036 | • | • | • | N20 | 9V–16V | 75 dB Volume<br>± 15 dB Tone | 80 dB | 0.06 % | 75 dB | Similar to LM1035 with 0.3 VRMS input level. |
| LM1040 | • | • | • | N24 | 9V–16V | 75 dB Volume<br>± 15 dB Tone | 80 dB | 0.06 % | 75 dB | Similar to LM1036 with stereo enhancement feature. |
| LMC835 | | • | | N28 | 5V–16V | ± 12 dB<br>± 6 dB Selectable | 114 dB | 0.0015 % | | Dual 7 band equalizer. 0.1 dB gain accuracy digital control. |
| LMC1992 | | • | • | N28 | | 80 dB Volume<br>40 dB Fader<br>± 12 dB Tone | 92 dB | 0.03 % | 80 dB | Digital control. Loudness, tone, volume, 3 input stereo selector. All levels in 2 dB steps. |
| LM1037 | • | • | • | N18 | 5V–28V | – 90 db | 106 dB | 0.04 % | 95 dB | Four channel analog switch; mute. TTL compatible. |
| LM1038 | • | • | • | N18 | 5V–28V | – 90 dB | 106 dB | 0.04 % | 95 dB | Similar to LM1037, 2 bit control. |

## Video/TV Circuit Selection Guide

National Semiconductor entered the video world in the 1970's with ICs for home television.

National's broadband expertise is now being applied to ICs for high resolution monitors. Our latest device, the LM1203, offers three 70 MHz video processing channels on a single chip.

### Video Processing Circuits

| | |
|---|---|
| LM1201 | Video Amplifier System |
| LM1203 | RGB Video Amplifier System |
| LM1823 | Video IF/Synchronous Detector |
| LM1880 | No Hold Vertical/Horizontal |
| LM1881 | Video Sync Separator |

### TV Peripheral Circuits

| | |
|---|---|
| LM1017 | 4-Bit Binary, 7-Segment Decoder/Driver |
| LM1886 | TV Video Matrix D/A |
| LM1889 | TV Video Modulator (Color) |
| LM2889 | TV Video Modulator (B/W) |

### Video Amplifiers

| | |
|---|---|
| LM592 | Differential Video Amplifier |
| LM733 | Differential Video Amplifier |

## Sensor Selection Guide

### Temperature Sensors

| | |
|---|---|
| LM34 | Precision Fahrenheit Temperature Sensor |
| LM35 | Precision Centigrade Temperature Sensor |
| LM334 | Current Mode Temperature Sensor |
| LM335 | Precision Temperature Sensor |
| LM3911 | Temperature Controller |

### Fluid Level Detectors

| | |
|---|---|
| LM1030 | Fluid Level Detector |
| LM1042 | Analog Fluid Level Output |
| LM1830 | Fluid Level Detector |

### Others

| | |
|---|---|
| LM1812 | Ultrasonic Transceiver |
| LM1815 | Adaptive Sense Amplifier |
| LM1851 | Ground Fault Interrupter |
| LM1964 | Oxygen Sensor Amplifier |

## Tone Control Circuit Selection Guide

The National Semiconductor range of tone, volume and balance circuits operating under DC control provides a cost effective solution for circuit design.

In addition, a microprocessor compatible graphic equalizer — the LMC835 — complements this range of circuits.

### Tone Controllers

| | |
|---|---|
| LM1035 | Dual Tone, Volume, Balance |
| LM1036 | Dual Tone, Volume, Balance |
| LM1040 | Dual Tone, Volume, Balance with Stereo Enhancement |
| LMC835 | Digitally Controlled Graphic Equalizer<br>—14-Band Mono<br>—7-Band Stereo |
| LMC1992 | Digitally Controlled Tone/Vol/Bal/Fader/Loudness |

## Timer Selection Guide

| | LM322 | LM2905 | LM555 | LMC555*<br>(CMOS LM555) | LM556<br>(Dual LM555) |
|---|---|---|---|---|---|
| Shortest Output Pulse | | | | | |
| Longest Output Pulse | 2.8 Hours | 2.8 Hours | 20 Minutes | 20 Minutes | 20 Minutes |
| Trigger Pulse Relative to Output Pulse | Can be Longer | Can be Longer | Must be Shorter | Must be Shorter | Must be Shorter |
| Typical Application | Monostable | Monostable | Astable | Astable | Astable |
| Supply Voltage | 4.5–40V | 4.5 – 40V | 4.5–15V | 1.2–12V | 4.5–15V |
| Supply Current (Typical) | 2.5 mA | 2.5 mA | 10 mA | 0.15 mA | 10 mA (Each Timer Section) |
| Devices Offered (Refer to Datasheet or R.E.T.S. for Specifications) | LM122H<br>LM122H/883<br>LM322H<br>LM322N | LM2905N<br>LM3905N<br>(Refer to LM122/322 Datasheet) | LM555CH<br>LM555CJ<br>LM555CM<br>LM555CN<br>LM555H<br>LM555H/883<br>LM555J<br>LM555J/883 | LMC555CH<br>LMC555CM<br>LMC555CN<br>LMC555H/883 | LM556CJ<br>LM556CM<br>LM556CN<br>LM556J<br>LM556J/883 |
| Additional Applications Information (Refer to 1986 Linear Applications Handbook) | AN-97<br>LB-38 | | AB-7 | | AB-7 |

*The CMOS LMC555 can handle up to + 10/ − 50 mA of output current and the bipolar LM555 can handle up to ± 200 mA of output current.

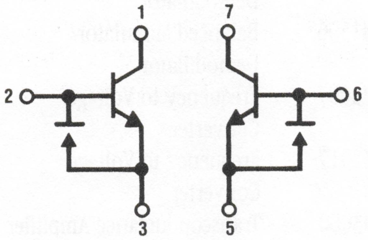
## Transistor Array Selection Guide

### Special Transistors

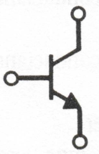
| | |
|---|---|
| LM194 | Supermatched Transistor Pair |
| LM195 | Ultrareliable Power Transistor |
| LM295 | Ultrareliable Power Transistor |
| LM394 | Supermatched Transistor Pair |
| LM395 | Ultrareliable Power Transistor |

### Transistor Arrays

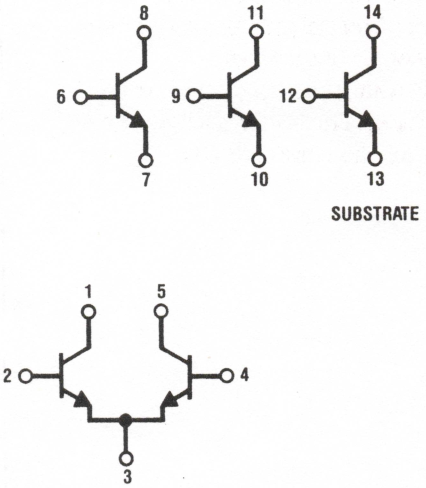
| | |
|---|---|
| LM3045 | Transistor Array |
| LM3046 | Transistor Array |
| LM3086 | Transistor Array |
| LM3146 | High Voltage Transistor Array |



LM194/LM394



LM195
LM295
LM395
(CURRENT LIMIT, THERMAL LIMIT,
SAFE AREA PROTECTION)



LM3045
LM3046
LM3086
LM3146

## Automotive Circuit Selection Guide

National Semiconductor offers a wide range of products for the automotive industry including A/D, D/A converters, operational amplifiers and voltage regulators. All the devices perform over the entire automotive temperature range.

For more details, please refer to the appropriate product selection guide.

### Dashboard Circuits

| | |
|---|---|
| LM1030 | Fluid Level Detector |
| LM1042 | Analog Output Fluid Level IC |
| LM1819 | Aircore Meter Driver |
| LM1830 | Fluid Detector |
| LM1946 | Over/Under Current Detector |
| LM3909 | LED Flasher |

### Controller Circuits

| | |
|---|---|
| LM35 | Centigrade Temperature Sensor |
| LM334 | Current Mode Temperature Sensor |
| LM335 | Temperature Sensor |
| LM675 | Power Operational Amplifier |
| LM1815 | Adaptive Sense Amplifier |
| LM1949 | Injector Driver Controller |
| LM1951 | 1A Intelligent Switch |
| LM1964 | Sensor Interface Amplifier |
| LM2907 | Frequency to Voltage Converter |
| LM2917 | Frequency to Voltage Converter |
| LM3080 | Operational Transconductance Amplifier |
| LM3911 | Temperature Controller |
| LM13600 | Dual Transconductance Amplifier |
| LM13700 | Dual Transconductance Amplifier |
| LM18272 | Power Op Amp |
| LM18293 | Dual H Switch |

## Industrial Building Block Selection Guide

Additional standard functions such as amplifiers and voltage regulators are available from National Semiconductor. Please refer to the appropriate product selection guide.

### Standard Blocks

| | |
|---|---|
| LM555 | Timer |
| LM556 | Dual Timer |
| LM565 | Phase Locked Loop |
| LM566 | Voltage Controlled Oscillator |
| LM567 | Tone Decoder |
| LM675 | Power Operational Amplifier |
| LM1211 | Broadband Demodulator System |
| LM1391 | Phase Locked Loop |
| LM1496 | Balanced Modulator/Demodulator |
| LM1596 | Balanced Modulator/Demodulator |
| LM2907 | Frequency to Voltage Converter |
| LM2917 | Frequency to Voltage Converter |
| LM3080 | Transconductance Amplifier |
| LM3909 | LED Flasher/Oscillator |
| LM13600 | Dual Transconductance Amplifier |
| LM13700 | Dual Transconductance Amplifier |
| LMC555 | CMOS Timer |
| LMC567 | Low Power Tone Decoder |
| LMC568 | Low Power Phase Locked Loop |

### Special Blocks

| | |
|---|---|
| LM621 | Commutator Block for DC Motors |
| LM622 | DC Motor Driver |
| LM909 | Remote Control Receiver |
| LM1801 | Battery Operated Power Comparator |
| LM1812 | Ultrasonic Transceiver |
| LM1815 | Adaptive Sense Amplifier |
| LM1830 | Fluid Level Detector |
| LM1851 | Ground Fault Interrupter |
| LM1871 | RC Encoder/Transmitter |
| LM1872 | RC Receiver/Decoder |
| LM1893 | Current Carrier Transceiver |
| LM1921 | 1A Industrial Switch |
| LM1946 | Over/Under Current Detector |
| LM1951 | 1A Intelligent Switch |
| LM2893 | Advanced Carrier Current Transceiver |
| LM3361A | Narrow Band IF System (Cordless Phone) |
| LM3914 | Dot/Bar Display Driver (Linear) |
| LM3915 | Dot/Bar Display Driver (Log) |
| LM3916 | Dot/Bar Display Driver (VU) |

# Logic

For additional Logic products, see pages 273 and 423.

# Logic Device Families

## TTL Logic (DM54/DM74)

TTL logic was the first saturating logic integrated circuit family introduced, thus setting the standard for all the future families. It offers a combination of speed, power consumption, output source and sink capabilities suitable for most applications. This family offers the greatest variety of logic functions. The basic gate (Figure 1) features a multiple-emitter input configuration for fast switching speeds, active pull-up output to provide a low driving source impedance which also improves noise margin and device speed. Typical device power dissipation is 10 mW per gate and the typical propagation delay is 10 ns when driving a 15 pF/400Ω load.

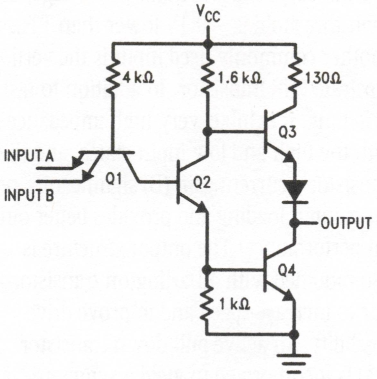


**Figure 1. DM5400/DM7400**

## CMOS Logic (CD4XXX, MM54/74C, MM54/74HC, MM54/74 HCT)

The CD4000 series is National Semiconductor's extensive line of CD40XXB and CD45XXB series devices. These parts meet the standard JEDEC "B-series" specifications.

The popular MM54C/74C series logic family metal-gate CMOS technology is pin-for-pin and function-for-function equivalent to the 54/74 family of TTL devices. Unique special function LSI devices in this family are compatible with MM54HC/74HC and CD4000 series.

## Advanced Schottky (DM74AS)

This family of devices is designed to meet the needs of the system designers who require the ultimate in speed. Utilizing Schottky barrier diode clamped transistors with shallower diffusions and advanced oxide-isolation fabrication techniques, the AS family achieves the fastest propagation delay that bipolar technology can offer. The AS family has virtually the same circuit configuration as the ALS family. It has PNP transistor or diode inputs with electrostatic protection base-emitter shorted transistors. The output totempole consists of a Darlington pair transistor pull-up and an active pull-down squaring network. The inputs and outputs are Schottky clamped to attenuate critical transmission line reflections. In addition, the circuit contains the "Miller Killer" network at the output section to improve output rise time and reduce power consumption during switching at high repetition rates. The AS family yields typical power dissipation of 7 mW per gate and propagation delay time of 1.5 ns when driving a 50 pF/2 kΩ load.

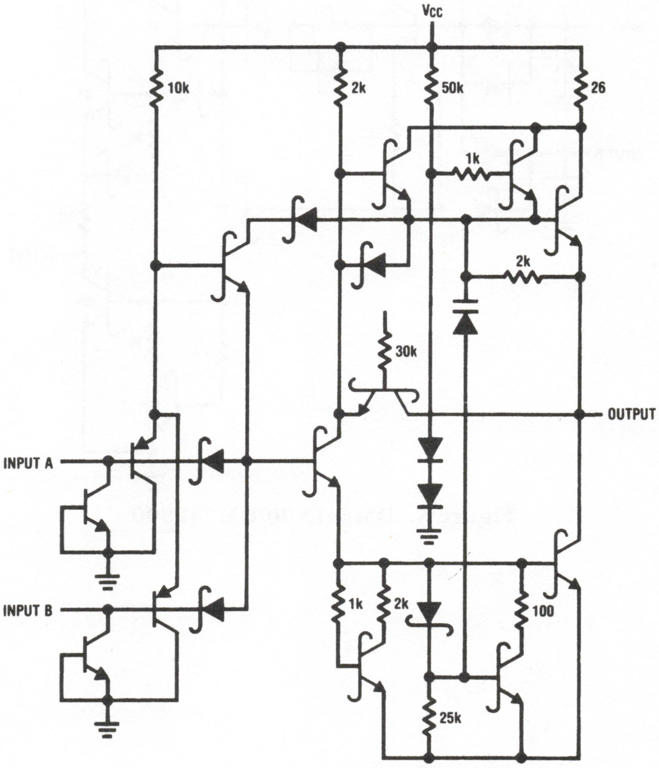


**Figure 2. DM74AS00**

## Low Power Schottky (DM54LS/DM74LS)

The low power Schottky family features a combined fivefold reduction in current and power when compared to the TTL family. Gold doping commonly used in the TTL devices reduces switching times at the expense of current gain. The LS process overcomes this limitation by using a surface barrier diode (Schottky diode) in the baker clamp configuration between the base and collector junction of the transistor. In this way, the transistor is never fully saturated and recovers quickly when base drive is interrupted. Using shallower diffusion and soft-saturating Schottky diode clamped transistors, higher current gains and faster turn-on times are obtained. The LS circuits do not use the multi-emitter inputs. They use diode-transistor inputs which are faster and give increased input breakdown voltage; the input threshold is ~ 0.1V lower than TTL. Another commonly used input is the vertical substrate PNP transistor. In addition to fast switching, it exhibits very high impedance at both the high and low input states, and the transistor's current gain (B) significantly reduces input loading and provides better output performance. The output structure is also modified with a Darlington transistor pair to increase speed and improve drive capability. An active pull-down transistor (Q3) is incorporated to yield a symmetrical transfer characteristic (squaring network). This family achieves circuit performance exceeding the standard TTL family at a fraction of its power consumption. The typical device power dissipation is 2 mW per gate and typical propagation delay is 10 ns while driving a 15 pF/2 kΩ load.

## Schottky (DM54S/DM74S)

This family features the high switching speed of unsaturated bipolar emitter-coupled logic, but consumes more power than standard TTL devices. To achieve this high speed, the Schottky barrier diode is incorporated as a clamp to divert the excess base current and to prevent the transistor from reaching deep saturation. The Schottky gate input and internal circuitry resemble the standard TTL gate except the resistor values are about one-half the TTL value. The output section has a Darlington transistor pair for pull-up and an active pull-down squaring network. This family has power dissipation of 20 mW per gate and propagation delays three times as fast as TTL devices with the average time of 3 ns while driving 15 pF/280Ω load.

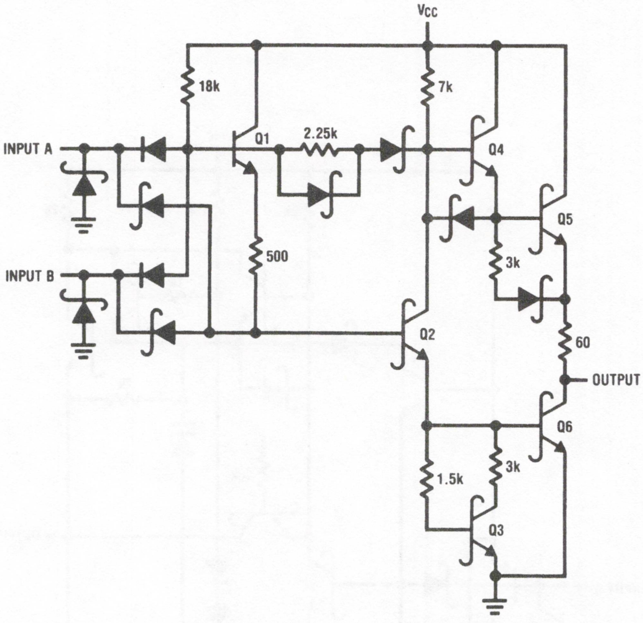


Figure 3. DM54LS00/DM74LS00

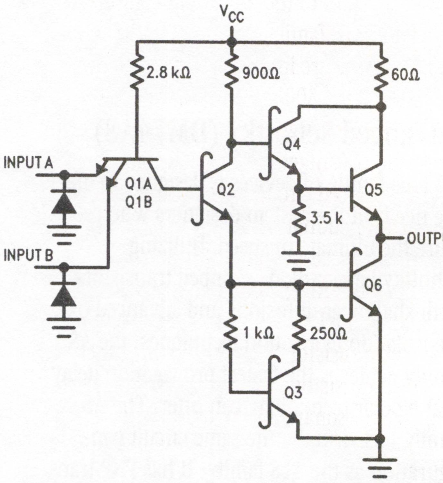


Figure 4. DM54S00/DM74S00

## Advanced Low Power Schottky (DM74ALS)

The advanced low power Schottky family is one of the most advanced TTL families. It delivers twice the data handling efficiency and still provides up to 50 % reduction in power consumption compared to the LS family. This is possible because of a new fabrication process where components are isolated by a selectively grown thick-oxide rather than the P-N junction used in conventional processes. This refined process, coupled with improved circuit design techniques, yields smaller component geometries, shallower diffusions, and lower junction capacitances. This enables the devices to have increased $f_T$ in excess of 5 GHz and improved switching speeds by a factor of two, while offering much lower operating currents.

In addition to the pin-to-pin compatibility of the ALS family, a number of MSI and LSI functions are introduced in the high density 24-pin 300 mil DIP. These devices offer the designers greater cost effectiveness with the advantages of reduced component count, reduced circuit board real-estate, increased functional capabilities per device and improved speed-power performance.

The basic ALS gate schematic is quite similar to the LS gate. It consists of either the PNP transistor or the diode inputs, Darlington transistor pair pull-up and active pull-down (squaring network) at the output. Since the shallower diffusions and thinner oxides will cause ALS devices to be more susceptible to damage from electrostatic discharge, additional protection via a base-emitter shorted transistor is included at the input for rapid discharge of high voltage static electricity. Furthermore, the inputs and outputs are clamped by Schottky diodes to prevent them from swinging excessively below ground level. A buried N$^+$ guard ring around all input and output structures prevents crosstalk. The ALS family has a typical power dissipation of 1 mW per gate and typical propagation delay time of 4 ns into a 50 pF/2 kΩ load.

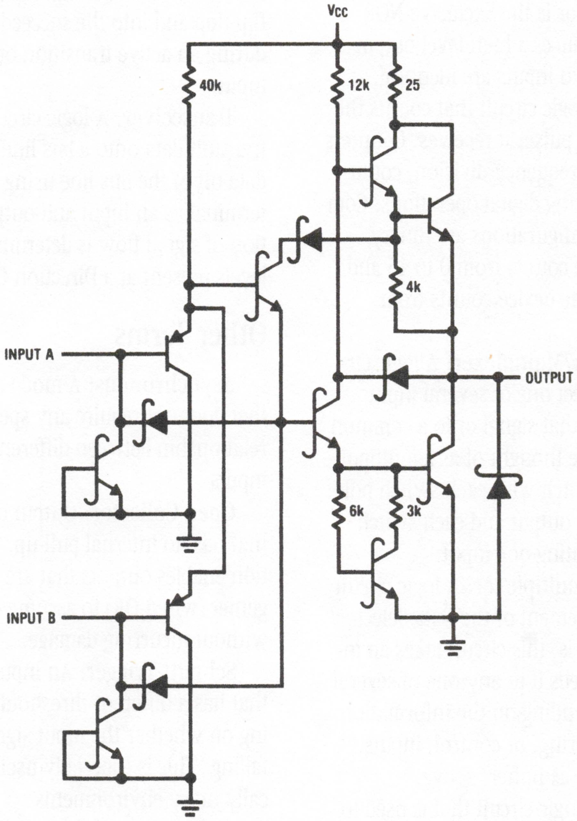


**Figure 5. DM74ALS00**

## Functional Descriptions

**Buffer:** A logic gate with high output drive capability, or fan-out. Buffers are used where a single circuit must drive a large number of loads.

**Comparator:** A logic circuit that will compare two separate input signals and produce an output based on that comparison. A simple comparator is the Exclusive-NOR gate, which produces a high level output only when its two inputs are identical.

**Counter:** A logic circuit that counts the number of input pulses it receives. Counters can be used for frequency division, counting, and sequencing digital operations. Common counter configurations are Binary, where the device counts from 0 to 15 and Decade, where the device counts from 0 to 9.

**Data Selector/Multiplexer:** A logic circuit that will select one of several input signals and feed that signal onto a common bus line. It can be thought of as a multipole, multiposition switch with each switch pole representing one output and each switch position representing one input.

**Decoder/Demultiplexer:** A logic circuit that is the complement of the Data Selector/Multiplexer; that is, this circuit takes an input signal and feeds it to any one of several output lines depending on the information placed on its steering, or control, inputs.

**Driver:** Same as Buffer, above.

**Flip-Flop:** A logic circuit that is used to store information. A flip-flop is called "bistable" since it has two stable states.

**Gate:** The basic building block of all logic circuits; an element whose output is a Boolean function of its inputs. The basic functions are the AND, OR, and NOT. By combining these functions, NAND, NOR, and Exclusive-OR and Exclusive-NOR gates are built.

**Latch:** A bistable element that latches, or holds, data which is present at its input at the time the Enable input goes to its inactive state. When the Enable input is active, the data, present at the input, is passed directly to the output, similar to the operation of a gate.

**One-Shot:** Monostable multivibrator; a flip-flop that only has one stable state. When triggered by an input transient, it flips to its unstable state for a time period determined by an external R-C network connected to its timing inputs, and then returns to its stable state.

**Shift Register:** A series of flip-flops in which the data signal is shifted out of one flip-flop and into the succeeding flip-flop during an active transition on the clock input.

**Transceiver:** A logic circuit that can transmit data onto a bus line and receive data off of the bus line using the same terminal as an input and output. The direction of signal flow is determined by logic levels present at a Direction Control input.

## Other Terms

**Asynchronous:** A mode of operation that does not require any specific timing relationship between different control inputs.

**Open Collector:** Output configuration that has no internal pull-up. This configuration enables outputs that are connected together (wired-OR) to assume opposite states without incurring damage.

**Schmitt Trigger:** An input configuration that has a different threshold point depending on whether the input signal is rising or falling. This is especially useful in electrically noisy environments.

**Synchronous:** A mode of operation where specific timing requirements must be met between control inputs before an indicated action can occur.

**Totem Pole:** An output configuration that contains an internal pull-up structure, usually a transistor pull-up allowing higher output drive capability than is available with open collector outputs.

**TRI-STATE:** A registered trademark for a circuit configuration in which the device output can be switched 'off' during which time the output presents a very high impedance to the bus it is connected to. This allows multiple outputs to be connected to a bus line while only one output drives the line, the other outputs being switched into their high impedance states.

## Explanation of Function Tables

The following symbols are used in the function tables found in NSC data sheets:

H = high logic level (steady state)
L = low logic level (steady state)
↑ = transition from low to high logic level
↓ = transition from high to low logic level
X = irrelevent (any level, including transitions)
Z = off (high impedance) state of a TRI-STATE output
a...h = the level of steady state inputs at inputs A through H respectively
$Q_0$ = the level of Q before the indicated steady state input conditions were established
$Q_0$ = complement of $Q_0$ or level of Q before the indicated steady state input conditions were established
$Q_n$ = level of Q before the most recent active transition indicated by ↑ or ↓
⎍ = one high level pulse
⊔ = one low level pulse
toggle = each output changes to the complement of its previous level on each active transition indicated by ↑ or ↓

If, in the input columns, a row contains only the symbols H, L, and/or X, this means the indicated output is valid whenever the input configuration is achieved regardless of the sequence in which it is achieved. The output persists so long as the input configuration is maintained.

## How to Read Digital Products Selection Tables

The following symbols are common to all selection tables

X = Product available in technology indicated

NP = New product planned in technology indicated

The complete device number is composed of a technology prefix plus a device number suffix. For example, hex 2-input NAND gates are available in the following device numbers:

DM74ALS804
DM74AS804B

For further information on military processing of these products or information on obtaining a current catalog, please contact your local National sales office, distribution office or contact National directly.

| Technology | Device Prefix/Suffix |
|---|---|
| TTL | (DM54/DM74) |
| Low Power | (DM54L/DM74L) |
| Low Power Schottky | (DM54LS/DM74LS) |
| Advanced Low Power Schottky | *(DM54ALS/DM74ALS) |
| Schottky | (DM54S/DM74S) |
| Advanced Schottky | (DM74AS) |
| High Speed CMOS | (MM54HC/MM74HC) |
| CMOS | (MM54C/MM74C) |
| High Speed Sub-family (Compatible with TTL) | (MM54HCT/MM74HCT) |
| Standard CMOS | CD4XXX |

* DM54ALS functions "selectively available".

## Package Information

| Technology | | | Standard TTL | Advanced Low Power Schottky TTL | Advanced Schottky TTL | Low Power Schottky TTL | Schottky TTL | High-Speed Silicon-Gate CMOS | CD4000 CMOS |
|---|---|---|---|---|---|---|---|---|---|
| Device Series | (0°C to +70°C) | 74 | 74 | 74ALS | 74AS | 74LS | 74S | | |
| | (−40°C to +85°C) | 74 | | | | | | 74HC | CD4XXXBC |
| | (−55°C to +125°C) | 54 | 54 | 54ALS | | 54LS | 54S | 54HC | CD4XXXBM |
| Packages Available | | 74 | J, N, M | N, FN, M | N, FN, M | J, N, FN, M | J, N, M | J, N, FH, FN | |
| | | 54 | J, W, FH | J, FH | J, FH | J, W, FH | J, W, FH | J, FH, FK | |

## Typical SSI Performance

The electrical characteristics of specific devices within each family may vary. Please consult the appropriate National data sheet or databook for complete specifications.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Power Dissipation/Gate | | (mW) | 10 | 1 | 10 | 2 | 19 | 0.001 + | 0.005 + |
| Propagation Delay Time | | (ns) | 10 | 4 | 1.5 | 9.5 | 3 | 10 | 125 |
| Speed-Power Product | | (pj) | 100 | 4 | 15 | 19 | 57 | | |
| Flip-Flop Clock Frequency, $f_{max}$ | | (MHz) | 35 | 50 | 175 | 45 | 125 | 40 | 2 |
| Input Low Current, $I_{IL}$ | | (mA) | −1.0 | −0.2 | −0.4 | −0.2 | −1.6 | ±0.001 | ±0.001 |
| Output Drive Current, $I_{OL}$ | Standard | (mA) | 16 | 8 | 20 | 8 | 20 | 4 | 0.4 |
| | Buffer | (mA) | 48 | 24 | 48 | 24 | 60 | 8 | |
| *Power Supply Range | | | 5V ± 5%* | 5V ± 10% | 5V ± 10% | | 5V ± 5%* | 2.6V | 3.15V |

*54 Series devices in these technologies are specified with power supplies of 5V ± 10%.

## Analog Switches

| Description | Device Number | (Logic Families) Technology ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | S 54/74 | TTL 54/74 |
|---|---|---|---|---|---|---|---|---|---|
| Quad Analog Switch | 4016 | | | | | X | | | |
| 8-Channel Analog Multiplexer | 4051 | | | | | X | | | |
| Dual 4-Channel Analog Multiplexer | 4052 | | | | | X | | | |
| Triple 2-Channel Analog Multiplexer | 4053 | | | | | X | | | |
| Quad Analog Switch | 4066 | | | | | X | | | |
| Quad Analog Switch with Level Translator | 4316 | | | | | X | | | |

## Arithmetic Functions

| Description | Device Number | (Logic Families) Technology ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
|---|---|---|---|---|---|---|---|---|---|---|
| 4-Bit Binary Full Adder | 83 | | | X | | | | | | |
| 4-Bit Binary Adder with Fast Carry | 83A | | | | | | | X | | |
| 4-Bit Magnitude Comparator | 85 | | | | | X | | X | | X |
| 9-Bit Parity Generator/Checker | 180 | | | | | | | | | X |
| Arithmetic Logic Unit/Function Generator | 181 | | | | | X | | | X | X |
| Arithmetic Logic Unit/Function Generator | 181B | | X | | | | | | | |
| Look-Ahead Carry Generator | 182 | | X | | | X | | | X | |
| BCD-to-Binary Converter | 184 | | | | | | | | | X |
| Binary-to-BCD Converter | 185A | | | | | | | | | X |
| 9-Bit Parity Generator/Checker | 280 | | X | | | X | | | X | |
| Look Ahead Carry Generator with Selectable Carry Inputs | 282 | | X | | | | | | | |
| 4-Bit Binary Adder with Fast Carry | 283 | | | | | X | | X | X | |
| Parity Generator/Checker | 286 | | X | | | | | | | |
| Arithmetic Logic Unit/Function Generator | 381 | | | | | | | | X | |
| 8-Bit Magnitude Comparator (Equality Detector) | 521 | X | | | | X | X | | | |
| 8-Bit Magnitude Comparator (Equality Detector) | 688 | | | | | X | X | | | |
| 4-Bit Full Adder | 4008BM | | | | X | | | | | |
| TRI-STATE 4-Bit Parallel Binary Multiplier | 7875A | | | | | | | | | X |
| TRI-STATE 4-Bit Parallel Binary Multiplier | 7875B | | | | | | | | | X |
| TRI-STATE 4-Bit Parallel Binary Multiplier | 8875A | | | | | | | | | X |
| TRI-STATE 4-Bit Parallel Binary Multiplier | 8875B | | | | | | | | | X |

## Buffers/Drivers

| Description | Device Number | (Logic Families) Technology<br>ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
|---|---|---|---|---|---|---|---|---|---|---|
| Hex Inverter | 04 | X | X | | | | | X | X | X |
| Hex Inverting Buffer/Driver with High-Voltage Open Collector Outputs | 06 | | | | | | | | | X |
| Hex Buffer/Driver with High-Voltage Open-Collector Outputs | 07 | | | | | | | | | X |
| Hex Schmitt Trigger Inverter | 14 | X | | | | | | X | | X |
| Hex Inverting Buffer/Driver with High-Voltage Open-Collector Outputs | 16 | | | | | | | | | X |
| Hex Buffer/Driver with High-Voltage Open-Collector Outputs | 17 | | | | | | | | | X |
| Quad 2-Input NAND Buffer with High-Voltage Open-Collector Outputs | 26 | | | | | | | X | | X |
| Quad 2-Input NOR Buffer | 28 | X | | | | | | | | |
| 8-Input NAND Gate | 30 | X | X | X | | | | X | X | X |
| Quad 2-Input NOR Buffer with Open-Collector Outputs | 33 | X | | | | | | | | |
| Quad 2-Input NAND Buffer | 37 | X | | | | | | X | | X |
| Quad 2-Input NAND Buffer with Open-Collector Outputs | 38 | X | | | | | | X | | X |
| Dual 4-Input NAND Buffer | 40 | X | | | | | | | X | |
| TRI-STATE Hex Buffer | 95 | | | X | | | | | | X |
| TRI-STATE Hex Inverter | 96 | | | X | | | | | | |
| TRI-STATE Hex Buffer | 97 | | | X | | | | | | |
| TRI-STATE Hex Inverter | 98 | | | X | | | | | | |
| Quad TRI-STATE Buffer | 125 | | | | | X | | | | X |
| Quad TRI-STATE Buffer | 125A | | | | | | | X | | |
| Quad TRI-STATE Buffer | 126 | | | | | X | | | | |
| Quad TRI-STATE Buffer | 126A | | | | | | | X | | |
| Dual 4-Input NAND 50Ω Line Driver | 140 | | | | | | | | X | |
| Octal TRI-STATE Bus Driver/Receiver with True and Inverting Outputs | 230 | | X | | | | | | | |
| Octal TRI-STATE Inverting Bus Driver/Receiver | 231 | | X | | | | | | X | |
| Octal TRI-STATE Inverting Buffer/Line Driver/Line Receiver | 240 | X | X | X | | X | X | X | X | |
| Octal TRI-STATE Buffer/Line Driver/Line Receiver | 241 | X | X | | | X | X | X | X | |
| Octal TRI-STATE Buffer/Line Driver/Line Receiver | 244 | X | X | X | | X | X | X | X | |
| Hex TRI-STATE Buffer | 365 | | | | | X | | | | X |
| Hex TRI-STATE Buffer/Bus Driver | 365A | | | | | | | X | | |
| Inverting Hex TRI-STATE Buffer | 366 | | | | | X | | | | |
| Inverting Hex TRI-STATE Buffer/Bus Driver | 366A | | | | | | | X | | |
| Hex TRI-STATE Buffer | 367 | | | | | | | | | X |
| Hex TRI-STATE Buffer/Bus Driver | 367A | | | | | | | X | | |
| Inverting Hex TRI-STATE Buffer | 368 | | | | | X | | X | | X |
| Octal TRI-STATE Buffer/Bus Driver | 465 | X | | | | | | X | | |
| Inverting Octal TRI-STATE Buffer/Bus Driver | 466 | X | | | | | | X | | |
| Octal TRI-STATE Buffer/Bus Driver | 467 | X | | | | | | X | | |
| Inverting Octal TRI-STATE Buffer/Bus Driver | 468 | X | | | | | | X | | |
| Inverting Octal TRI-STATE Buffer | 540 | | | | | X | X | | | |

## **Buffers/Drivers** (Continued)

| Description | Device Number | (Logic Families) Technology | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
| Inverting Octal TRI-STATE Buffer | 541 | X | | | | X | X | | | |
| Hex 2-Input NAND Line Driver | 804 | X | | | | | | | | |
| Hex 2-Input NAND Line Driver | 804A | | X | | | | | | | |
| Hex 2-Input NOR Line Driver | 805 | X | | | | | | | | |
| Hex 2-Input NOR Line Driver | 805A | | X | | | | | | | |
| Hex 2-Input AND Line Driver | 808 | X | | | | | | | | |
| Hex 2-Input AND Line Driver | 808A | | X | | | | | | | |
| Hex 2-Input OR Line Driver | 832 | X | | | | | | | | |
| Hex 2-Input OR Line Driver | 832A | | X | | | | | | | |
| Hex Inverting TTL Buffer | 901 | | | X | | | | | | |
| Hex Non-Inverting Buffer | 902 | | | X | | | | | | |
| Hex Inverting PMOS Buffer | 903 | | | X | | | | | | |
| Hex Non-Inverting PMOS Buffer | 904 | | | X | | | | | | |
| Hex Open Drain N-Channel Buffer | 906 | | | X | | | | | | |
| Hex Open Drain P-Channel Buffer | 907 | | | X | | | | | | |
| Dual CMOS 30V Relay Driver | 908 | | | X | | | | | | |
| 4-Digit LED Display Controller | 911 | | | X | | | | | | |
| 4-Digit BCD LED Display Controller Driver | 912 | | | X | | | | | | |
| Hex Schmitt Trigger with Extended Input Voltage | 914 | | | X | | | | | | |
| 6-Digit Hex LED Display Controller Driver | 917 | | | X | | | | | | |
| Dual CMOS 30V Relay Driver | 918 | | | X | | | | | | |
| Octal TRI-STATE Inverting Buffer | 940 | | | | | | | | X | |
| Octal TRI-STATE Buffer | 941 | | | | | | | | X | |
| 4-Character LED Alphanumeric Display Controller Driver (17-Segment) | 956 | | | X | | | | | | |
| Quad 2-Input NAND Buffer (ALS37) | 1000 | X | X | | | | | | | |
| Quad 2-Input NOR Buffer (ALS28) | 1002 | X | | | | | | | | |
| Quad 2-Input NAND Buffer with Open-Collector Outputs | 1003 | X | | | | | | | | |
| Hex Inverting Buffer | 1004 | X | X | | | | | | | |
| Hex Inverting Buffer with Open-Collector Outputs | 1005 | X | | | | | | | | |
| Quad 2-Input AND Buffer | 1008 | X | X | | | | | | | |
| Triple 3-Input NAND Buffer | 1010 | X | | | | | | | | |
| Triple 3-Input AND Buffer | 1011 | X | | | | | | | | |
| Dual 4-Input NAND Buffer (ALS40) | 1020 | | | X | | | | | | |
| Quad 2-Input OR Buffer | 1032 | | X | X | X | | | | | |
| Hex Non-Inverting Buffer | 1034 | | X | X | X | | | | | |
| Hex Non-Inverting Buffer with Open-Collector Outputs | 1035 | | | X | | | | | | |
| Quad 2-Input NOR Driver | 1036 | | X | | X | | | | | |
| Octal TRI-STATE Inverting Bus Driver/Receiver | 1240 | X | | X | | | | | | |
| Octal TRI-STATE Driver/Receiver | 1241 | X | | X | | | | | | |
| Octal TRI-STATE Driver/Receiver | 1244 | X | | X | | | | | | |

## Buffers/Drivers (Continued)

| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (Logic Families) Technology | | | | | | | | |
| Hex Inverting Buffer | 4009 | | | | X | | | | | |
| Hex Inverting Buffer | 4009C | | | | X | | | | | |
| Hex Non-Inverting Buffer | 4010 | | | | X | | | | | |
| Hex Non-Inverting Buffer | 4010C | | | | X | | | | | |
| Hex Inverting Buffer | 4049UBM | | | | X | | | | | |
| Hex Inverting Buffer | 4049UBC | | | | X | | | | | |
| Hex Non-Inverting Buffer | 4050BM | | | | X | | | | | |
| Hex Non-Inverting Buffer | 4050BC | | | | X | | | | | |
| Quad 2-Input NAND Schmitt Trigger | 4093BM | | | | X | | | | | |
| Quad 2-Input NAND Schmitt Trigger | 4039BC | | | | X | | | | | |
| Hex Non-Inverting TRI-STATE Buffer | 4503BM | | | | X | | | | | |
| Hex Non-Inverting TRI-STATE Buffer | 4503BC | | | | X | | | | | |
| BCD-to-7-Segment Latch/Decoder/Driver | 4511 | | | | | X | | | | |
| BCD-to-7-Segment Latch/Decoder/Driver for Liquid Crystal Displays | 4543 | | | | | X | | | | |
| Hex Schmitt Trigger (See CD40106 data sheet) | 4584BM | | | | X | | | | | |
| Hex Schmitt Trigger (See CD40106 data sheet) | 4584BC | | | | X | | | | | |
| Hex Schmitt Trigger | 40106BM | | | | X | | | | | |
| Hex Schmitt Trigger | 40106BC | | | | X | | | | | |

## CMOS Memories

| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (Logic Families) Technology | | | | | | | | |
| 64-Bit (16 × 4) TRI-STATE Random Access Memory | 89 | | | X | | | | | | |
| 256-Bit (256 × 1) TRI-STATE Random Access Memory | 200 | | | X | | | | | | |
| 256-Bit (64 × 4) TRI-STATE Random Access Memory | 910 | | | X | | | | | | |
| 64-Bit (16 × 4) TRI-STATE Random Access Memory | 989 | | | X | | | | | | |

## Comparators

| | | (Logic Families) Technology | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
| 4-Bit Magnitude Comparator | 85 | | | X | | | | X | | X |
| Octal 8-Bit Identity Comparator with Open-Collector Outputs | 518 | X | | | | | | | | |
| Octal 8-Bit Identity Comparator with Open-Collector Outputs | 519 | X | | | | | | | | |
| Octal 8-Bit Identity Comparator | 520 | X | | | | | | | | |
| Octal 8-Bit Identity Comparator | 521 | X | | | | | | | | |
| Octal 8-Bit Identity Comparator with Open-Collector Outputs | 522 | X | | | | | | | | |
| 10-Bit Magnitude Comparator with Open-Collector Outputs | 7130 | | | | | | | | | X |
| 6-Bit Unified Bus Comparator with Hysteresis on Bus Inputs | 7131 | | | | | | | | | X |
| 6-Bit Unified Bus Comparator with Hysteresis on Bus Inputs and Open-Collector Outputs | 7136 | | | | | | | | | X |
| 6-Bit Magnitude Comparator with Open-Collector Outputs | 7160 | | | | | | | | | X |
| 10-Bit Magnitude Comparator with Open-Collector Outputs | 8130 | | | | | | | | | X |

## Counters

| | | (Logic Families) Technology | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
| Synchronous 4-Bit Up/Down BCD Counter | 60 | | | | | | | | | |
| Synchronous 4-Bit Up/Down Binary Counter | 63 | | | | | | | | | |
| Decade Counter | 90 | | | X | | | | X | | X |
| 4-Bit Binary Counter | 93 | | | X | | | | X | | X |
| Synchronous 4-Bit Decade Counter with Asynchronous Clear | 160 | X | X | X | | X | | | | |
| Synchronous 4-Bit Decade Counter with Asynchronous Clear | 160A | | | | | | | X | | |
| Synchronous 4-Bit Binary Counter with Asynchronous Clear | 161 | X | X | X | | X | | | X | |
| Synchronous 4-Bit Binary Counter with Asynchronous Clear | 161A | | | | | | | X | | X |
| Synchronous 4-Bit Decade Counter with Asynchronous Clear | 162 | X | X | X | | X | | | | |
| Synchronous 4-Bit Binary Counter with Asynchronous Clear | 163 | X | X | X | | X | | | X | |
| Synchronous 4-Bit Binary Counter with Asynchronous Clear | 163A | | | | | | | X | | X |
| Synchronous 4-Bit Up/Down Decade Counter | 168 | X | X | | | | | | | |
| Synchronous 4-Bit Up/Down Binary Counter | 169 | X | X | | | | | | | |
| Synchronous 4-Bit Up/Down Binary Counter | 169A | | | | | | | X | | |
| Synchronous 4-Bit Up/Down Decade Counter with Mode Control | 190 | X | | | | X | | X | | |
| Synchronous 4-Bit Up/Down Binary Counter with Mode Control | 191 | X | | | | X | X | X | | X |
| Synchronous 4-Bit Up/Down Decade Counter with Dual Clock | 192 | X | | | | X | | | | |
| Synchronous 4-Bit Up/Down Decade Counter with Dual Clock | 193 | X | | X | | X | X | X | | X |

## Counters (Continued)

|  |  | (Logic Families) Technology |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
| Counter Look Ahead Carry Generator | 264 |  | X |  |  |  |  |  |  |  |
| Decade Counter | 290 |  |  |  |  |  |  | X |  |  |
| 4-Bit Binary Counter | 293 |  |  |  |  |  |  | X |  |  |
| Dual 4-Bit Decade Counter | 390 |  |  |  |  | X |  | X |  |  |
| Dual 4-Bit Binary Counter | 393 |  |  |  |  | X |  | X |  |  |
| 8-Bit Binary Counter with TRI-STATE Output Register | 590 |  |  |  |  | X | X |  |  |  |
| 8-Bit Binary Counter with Input Register | 592 |  |  |  |  | X | X |  |  |  |
| 8-Bit Binary Counter with Bidirectional Input Register/Counter Outputs | 593 |  |  |  |  | X | X |  |  |  |
| 4-Digit Counter with Multiplexed 7-Segment Output Driver | 925 |  |  | X |  |  |  |  |  |  |
| 4-Digit Counter with Multiplexed 7-Segment Output Driver | 926 |  |  | X |  |  |  |  |  |  |
| 4-Digit Counter with Multiplexed 7-Segment Output Driver | 927 |  |  | X |  |  |  |  |  |  |
| 4-Digit Counter with Multiplexed 7-Segment Output Driver | 928 |  |  | X |  |  |  |  |  |  |
| 4-1/2-Digit LCD Up Counter/Latch/Driver | 945 |  |  | X |  |  |  |  |  |  |
| 4-Digit LCD Up/Down Counter/Latch/Driver | 946 |  |  | X |  |  |  |  |  |  |
| 4-Digit LCD Up/Down Counter/Latch/Driver | 947 |  |  | X |  |  |  |  |  |  |
| Decade Counter/Divider with 10 Decoded Outputs | 4017 |  |  |  |  | X |  |  |  |  |
| Decade Counter/Divider with 10 Decoded Outputs | 4017BM |  |  |  | X |  |  |  |  |  |
| Decade Counter/Divider with 10 Decoded Outputs | 4017BC |  |  |  | X |  |  |  |  |  |
| Presettable Divide-by-N Counter | 4018BM |  |  |  | X |  |  |  |  |  |
| Presettable Divide-by-N Counter | 4018BC |  |  |  | X |  |  |  |  |  |
| 14-Stage Binary Counter | 4020 |  |  |  |  | X |  |  |  |  |
| 14-Stage Ripple-Carry Binary Counter/Divider | 4020BM |  |  |  | X |  |  |  |  |  |
| 14-Stage Ripple-Carry Binary Counter/Divider | 4020BC |  |  |  | X |  |  |  |  |  |
| Divide-by-8 Counter/Divider with 8 Decoded Outputs | 4022BM |  |  |  | X |  |  |  |  |  |
| Divide-by-8 Counter/Divider with 8 Decoded Outputs | 4022BC |  |  |  | X |  |  |  |  |  |
| 7-Stage Binary Counter | 4024 |  |  |  |  | X |  |  |  |  |
| 7-Stage Ripple-Carry Binary Counter/Divider | 4024BM |  |  |  | X |  |  |  |  |  |
| 7-Stage Ripple-Carry Binary Counter/Divider | 4024BC |  |  |  | X |  |  |  |  |  |
| Presettable Binary/Decade Up/Down Counter | 4029BM |  |  |  | X |  |  |  |  |  |
| Presettable Binary/Decade Up/Down Counter | 4029BC |  |  |  | X |  |  |  |  |  |
| 12-Stage Binary Counter | 4040 |  |  |  |  | X |  |  |  |  |
| 12-Stage Ripple-Carry Binary Counter/Divider | 4040BM |  |  |  | X |  |  |  |  |  |
| 12-Stage Ripple-Carry Binary Counter/Divider | 4040BC |  |  |  | X |  |  |  |  |  |
| 14-Stage Binary Counter | 4060 |  |  |  |  | X |  |  |  |  |
| 14-Stage Ripple-Carry Binary Counter/Divider | 4060BM |  |  |  | X |  |  |  |  |  |
| 14-Stage Ripple-Carry Binary Counter/Divider | 4060BC |  |  |  | X |  |  |  |  |  |
| Binary Rate Multiplier | 4089BM |  |  |  | X |  |  |  |  |  |
| Binary Rate Multiplier | 4089BC |  |  |  | X |  |  |  |  |  |

## Counters (Continued)

| | | (Logic Families) Technology | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
| BCD Up/Down Counter | 4510BM | | | | X | | | | | |
| BCD Up/Down Counter | 4510BC | | | | X | | | | | |
| Binary Up/Down Counter | 4516BM | | | | X | | | | | |
| Binary Up/Down Counter | 4516BC | | | | X | | | | | |
| Dual Synchronous Up Counter | 4518BM | | | | X | | | | | |
| Dual Synchronous Up Counter | 4518BC | | | | X | | | | | |
| Dual Synchronous Up Counter | 4520BM | | | | X | | | | | |
| Dual Synchronous Up Counter | 4520BC | | | | X | | | | | |
| Programmable Divide-by-n 4-Bit BCD Counter | 4522BM | | | | X | | | | | |
| Programmable Divide-by-n 4-Bit BCD Counter | 4522BC | | | | X | | | | | |
| Programmable Divide-by-n 4-Bit Binary Counter | 4526BM | | | | X | | | | | |
| Programmable Divide-by-n 4-Bit Binary Counter | 4526BC | | | | X | | | | | |
| BCD Rate Multiplier | 4527BM | | | | X | | | | | |
| BCD Rate Multiplier | 4527BC | | | | X | | | | | |
| Decade Counter with Asynchronous Clear | 40160BM | | | | X | | | | | |
| Decade Counter with Asynchronous Clear | 40160BC | | | | X | | | | | |
| Binary Counter with Asynchronous Clear | 40161BM | | | | X | | | | | |
| Binary Counter with Asynchronous Clear | 40161BC | | | | X | | | | | |
| Decade Counter with Asynchronous Clear | 40162BM | | | | X | | | | | |
| Decade Counter with Asynchronous Clear | 40162BC | | | | X | | | | | |
| Binary Counter with Asynchronous Clear | 40163BM | | | | X | | | | | |
| Binary Counter with Asynchronous Clear | 40163BC | | | | X | | | | | |
| Synchronous 4-Bit Up/Down Decade Counter | 40192BM | | | | X | | | | | |
| Synchronous 4-Bit Up/Down Decade Counter | 40192BC | | | | X | | | | | |
| Synchronous 4-Bit Up/Down Binary Counter | 40193BM | | | | X | | | | | |
| Synchronous 4-Bit Up/Down Binary Counter | 40193BC | | | | X | | | | | |

## Decoders/Encoders

| | | (Logic Families) Technology | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
| BCD-to-Decimal Decoder/Driver (NIXIE Drivers) | 41A | | | | | | | | | X |
| BCD-to-Decimal Decoder | 42 | | | X | | X | | X | | X |
| BCD-to-Decimal Decoder/Driver | 45 | | | | | | | | | X |
| BCD-to-7-Segment Decoder/Driver with Open-Collector Outputs | 46A | | | | | | | | | X |
| BCD-to-7-Segment Decoder/Driver with Open-Collector Outputs | 47A | | | | | | | | | X |
| BCD-to-7-Segment Decoder | 48 | | | X | | | | | | |
| 3-to-8 Line Decoder with Address Latches | 131 | X | | | | | | | | |
| 3-to-8 Line Decoder/Demultiplexer with Address Latches | 137 | X | | | | X | | | | |
| 3-to-8 Line Decoder/Demultiplexer | 138 | X | | | | X | X | X | X | |
| 139 Dual 2-to-4 Line Decoder/Demultiplexer | 139 | | | | | X | X | X | X | |
| BCD-to-Decimal Decoder/Driver | 141 | | | | | | | | | X |
| BCD-to-Decimal Decoder/Driver | 145 | | | | | | | | | X |
| 10-Line Decimal to 4-Line BCD Priority Encoder | 147 | | | | | X | | | | |
| 8-Line Decimal to 3-Line Octal Priority Encoder | 148 | | | | | | | | | X |
| 8-Line to 8-Line Priority Encoder | 149 | | | | | X | X | | | |
| 4-to-16 Line Decoder/Demultiplexer | 154 | | | X | | X | | X | | X |
| Dual 2-to-4 Line Decoder/1-to-4 Line Demultiplexer | 155 | | | | | X | X | X | | X |
| Dual 2-to-4 Line Decoder/1-to-4 Line Demultiplexer with Open-Collector Outputs | 156 | | | | | | | X | | |
| 3-to-8 Decoder with Address Latches | 237 | | | | | X | | | | |
| 7-Segment-to-BCD Converter | 915 | | | X | | | | | | |
| 16-Key Keyboard Encoder | 922 | | | X | | | | | | |
| 20-Key Keyboard Encoder | 923 | | | X | | | | | | |
| BCD-to-Decimal Decoder | 4028BC | | | | X | | | | | |
| BCD-to-Decimal Decoder | 4028BM | | | | X | | | | | |
| BCD-to-7-Segment Latch/Decoder/Driver | 4511BC | | | | X | | | | | |
| BCD-to-7-Segment Latch/Decoder/Driver | 4511BM | | | | X | | | | | |
| 4-to-16 Line Decoder with Latch | 4514 | | | X | X | | | | | |
| 4-Bit Latched 4-to-16 Line Decoder | 4515BC | | | | X | | | | | |
| 4-Bit Latched 4-to-16 Line Decoder | 4515BM | | | | X | | | | | |
| Dual 4-Channel or Single 8-Channel Analog Data Selector | 4529BC | | | | X | | | | | |
| Dual 4-Channel or Single 8-Channel Analog Data Selector | 4529BM | | | | X | | | | | |
| BCD-to-7-Segment Latch/Decoder/Driver for Liquid Crystal Displays | 4543BC | | | | X | | | | | |
| 4-to-16 Line Decoder/Demultiplexer | 8311 | | | | | | | | | X |
| 8-to-3 Line Priority Encoder | 8318 | | | | | | | | | X |
| 8-to-3 Line Priority Encoder | 9318 | | | | | | | | | X |

## Error Correction/Detection Circuits

| | | (Logic Families) Technology | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
| TRI-STATE 32-Bit Error Detection and Correction Circuit | 632 | X | | | | | | | | |
| 32-Bit Error Detection and Correction Circuit with Open-Collector Outputs | 633 | X | | | | | | | | |
| TRI-STATE 32-Bit Error Detection and Correction Circuit | 634 | X | | | | | | | | |
| 32-Bit Error Detection and Correction Circuit with Open-Collector Outputs | 635 | X | | | | | | | | |

## Flip-Flops

| | | (Logic Families) Technology | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
| Dual J-K Flip-Flop with Clear | 73 | | | X | | X | | X | | X |
| Dual J-K Negative-Edge-Triggered Flip-Flop with Clear | 73A | | | | | | | X | | |
| Dual D Flip-Flop with Preset and Clear | 74 | | X | X | | X | X | | X | X |
| Dual D Positive-Edge-Triggered Flip-Flop with Preset and Clear | 74A | X | | | | | | X | | |
| Dual J-K Flip-Flop with Preset and Clear | 76 | | | X | | X | X | | | X |
| Dual J-K Negative-Edge-Triggered Flip-Flop with Preset and Clear | 76A | | | | | | | X | | |
| Dual J-K Flip-Flop with Clear | 107 | | | X | | X | | | | X |
| Dual J-K Negative-Edge-Triggered Master-Slave Flip-Flop with Clear | 107A | | | | | | | X | | |
| Dual J-K Flip-Flop with Preset and Clear | 109 | | X | | | X | X | | | X |
| Dual J-K Positive-Edge-Triggered Flip-Flop with Preset and Clear | 109A | X | | | | | | X | | |
| Dual J-K Flip-Flop with Preset and Clear | 112 | | | | | X | X | | X | |
| Dual J-K Negative-Edge-Triggered Flip-Flop with Preset and Clear | 112A | | | | | | | X | | |
| Dual J-K Flip-Flop with Preset | 113 | | | | | X | | | X | |
| TRI-STATE Quad D Flip-Flop | 173 | | | X | | X | | | | |
| Hex D Flip-Flop with Clear | 174 | X | X | X | | X | | X | X | X |
| Quad D-Type Flip-Flop with Clear | 175 | X | X | X | | X | | X | X | X |
| Octal D Flip-Flop with Clear | 273 | X | | | | X | X | | | |
| TRI-STATE Octal D-Type Flip-Flop | 374 | X | X | X | | X | X | X | X | |
| TRI-STATE Octal D-Type Flip-Flop with Inverted Outputs | 534 | X | X | | | X | X | | | |
| TRI-STATE Octal D-Type Flip-Flop with Inverted Outputs | 564 | X | | | | X | X | | | |
| Octal TRI-STATE D-Type Flip-Flop | 574 | X | X | | | X | X | | | |
| Octal TRI-STATE Positive-Edge-Triggered D Flip-Flop with Synchronous Clear | 575 | | X | | | | | | | |

## **Flip-Flops** (Continued)

| | | (Logic Families) Technology | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Description** | **Device Number** | **ALS 74** | **AS 74** | **C 54/74** | **CD 4** | **HC 54/74** | **HCT 54/74** | **LS 54/74** | **S 54/74** | **TTL 54/74** |
| Octal TRI-STATE Inverting Positive-Edge-Triggered D Flip-Flop | 576 | X | X | | | | | | | |
| Octal TRI-STATE Inverting Positive-Edge-Triggered D Flip-Flop with Synchronous Clear | 577 | | X | | | | | | | |
| Dual TRI-STATE 4-Bit Positive-Edge-Triggered D Flip-Flop | 874 | X | X | | | | | | | |
| Dual 4-Bit Inverting Positive-Edge-Triggered D Flip-Flop | 876 | X | X | | | | | | | |
| Dual 4-Bit Positive-Edge-Triggered D Flip-Flop with Synchronous Clear | 878 | | X | | | | | | | |
| Dual 4-Bit Inverting Positive-Edge-Triggered D Flip-Flop with Synchronous Preset | 879 | | X | | | | | | | |
| Dual D Flip-Flop | 4013BC | | | | X | | | | | |
| Dual D Flip-Flop | 4013BM | | | | X | | | | | |
| Dual J-K Master/Slave Flip-Flop with Set and Reset | 4027BC | | | | X | | | | | |
| Dual J-K Master/Slave Flip-Flop with Set and Reset | 4027BM | | | | X | | | | | |
| Quad Clocked D Latch | 4042BC | | | | X | | | | | |
| Quad Clocked D Latch | 4042BM | | | | X | | | | | |
| TRI-STATE NOR R/S Latch | 4043BC | | | | X | | | | | |
| TRI-STATE NOR R/S Latch | 4043BM | | | | X | | | | | |
| TRI-STATE NAND R/S Latch | 4044BC | | | | X | | | | | |
| TRI-STATE NAND R/S Latch | 4044BM | | | | X | | | | | |
| TRI-STATE Quad Flip-Flop | 4076BC | | | | X | | | | | |
| TRI-STATE Quad Flip-Flop | 4076BM | | | | X | | | | | |
| 8-Bit Addressable Latch | 4099BC | | | | X | | | | | |
| 8-Bit Addressable Latch | 4099BM | | | | X | | | | | |
| Dual 4-Bit Addressable Latch | 4723BC | | | | X | | | | | |
| Dual 4-Bit Addressable Latch | 4723BM | | | | X | | | | | |
| 8-Bit Addressable Latch | 4724BC | | | | X | | | | | |
| 8-Bit Addressable Latch | 4724BM | | | | X | | | | | |
| Dual Positive-Edge-Triggered J-K Flip-Flop with Preset and Clear | 8024 | | | | | | | | | X |
| Dual Positive-Edge-Triggered J-K Flip-Flop with Preset and Clear | 9024 | | | | | | | | | X |
| Hex D Flip-Flop | 40174BC | | | | X | | | | | |
| Hex D Flip-Flop | 40174BM | | | | X | | | | | |
| Quad D Flip-Flop | 40175BC | | | | X | | | | | |
| Quad D Flip-Flop | 40175BM | | | | X | | | | | |

## Gates/Inverters

| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (Logic Families) Technology | | | | | | | | |
| Quad 2-Input NAND Gate | 00 | X | X | X | | X | X | X | | X |
| Quad 2-Input NAND Gate with Open-Collector Outputs | 01 | X | | | | | | | | X |
| Quad 2-Input NOR Gate | 02 | X | X | X | | X | | X | X | X |
| Quad 2-Input NAND Gate with Open-Collector Outputs | 03 | X | | | | X | | X | X | X |
| Hex Inverter | 04 | X | X | | | X | X | X | X | X |
| Hex Inverter | U04 | | | | | X | | | | |
| Hex Inverter with Open-Collector Outputs | 05 | X | | | | | X | X | X | X |
| Quad 2-Input AND Gate | 08 | X | X | X | | X | X | X | X | X |
| Quad 2-Input AND Gate with Open-Collector Outputs | 09 | X | | | | | | X | X | X |
| Triple 3-Input NAND Gate | 10 | X | X | X | | X | | X | X | X |
| Triple 3-Input AND Gate | 11 | X | X | | | X | | X | X | |
| Triple 3-Input NAND Gate with Open-Collector Outputs | 12 | X | | | | | | X | | |
| Dual 4-Input Schmitt Trigger NAND Gate | 13 | X | | | | | | | | |
| Hex Schmitt Trigger Inverter | 14 | X | | | | X | | X | | X |
| Triple 3-Input AND Gate with Open-Collector Outputs | 15 | X | | | | | | | | |
| Dual 4-Input NAND Gate | 20 | X | X | X | | X | | X | X | X |
| Dual 4-Input AND Gate | 21 | X | X | | | | | X | | |
| Dual 4-Input NAND Gate with Open-Collector Outputs | 22 | X | | | | | | | | |
| Triple 3-Input NOR Gate | 27 | X | X | | | X | | X | | X |
| 8-Input NAND Gate | 30 | X | X | X | | X | | X | X | X |
| Quad 2-Input OR Gate | 32 | X | X | X | | X | | X | X | X |
| Hex Non-Inverter | 34 | | X | | | | X | | | |
| Dual AND-OR-Invert Gate | 51 | | | | | X | | X | X | |
| Dual AND-OR Gate | 58 | | | | | X | | | | |
| 4-Wide AND-OR-Invert Gate | 64 | | | | | | | | X | |
| Quad Exclusive-OR Gate | 86 | | X | X | | X | | X | X | X |
| Quad 2-Input Schmitt Trigger NAND Gate | 132 | X | | | | X | | X | | X |
| 13-Input NAND Gate | 133 | X | | | | X | | | X | |
| Quad Exclusive-OR Gate with Open-Collector Outputs | 136 | X | X | | | | | | | |
| Quad 2-Input Exclusive NOR Gate | 266 | | | | | X | | | | |
| Quad Exclusive-OR Gate | 386 | | | | | | | X | | |
| Quad 2-Input Exclusive NOR Gate | 810 | X | X | | | | | | | |
| Quad 2-Input Exclusive NOR Gate with Open-Collector Outputs | 811 | X | X | | | | | | | |
| Quad Comparator | 909 | | | X | | | | | | |
| Dual Input NOR Gate Plus Inverter | 4000C | | | | X | | | | | |
| Dual Input NOR Gate Plus Inverter | 4000M | | | | X | | | | | |
| Quad 2-Input NOR Gate | 4001C | | | | X | | | | | |
| Quad 2-Input NOR Gate | 4001M | | | | X | | | | | |
| Dual 4-Input NOR Gate | 4002 | | | | X | | | | | |

## Gates/Inverters (Continued)

| | | (Logic Families) Technology | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
| Dual 4-Input NOR Gate | 4002C | | | | X | | | | | |
| Dual 4-Input NOR Gate | 4002M | | | | X | | | | | |
| Dual Complementary Pair Plus Inverter | 4007C | | | | X | | | | | |
| Dual Complementary Pair Plus Inverter | 4007M | | | | X | | | | | |
| Quad 2-Input NAND Gate | 4011C | | | | X | | | | | |
| Quad 2-Input NAND Gate | 4011M | | | | X | | | | | |
| Quad 2-Input NAND Buffered B Series Gate | 4011BC | | | | X | | | | | |
| Quad 2-Input NAND Buffered B Series Gate | 4011BM | | | | X | | | | | |
| Dual 4-Input NAND Gate | 4012C | | | | X | | | | | |
| Dual 4-Input NAND Gate | 4012M | | | | X | | | | | |
| Dual 4-Input Buffered NAND Gate | 4012BC | | | | X | | | | | |
| Dual 4-Input Buffered NAND Gate | 4012BM | | | | X | | | | | |
| Quad AND-OR Select Gate | 4019BC | | | | X | | | | | |
| Quad AND-OR Select Gate | 4019BM | | | | X | | | | | |
| Triple 3-Input NOR Gate | 4023C | | | | X | | | | | |
| Triple 3-Input NOR Gate | 4023M | | | | X | | | | | |
| Triple 3-Input Buffered NAND Gate | 4023BC | | | | X | | | | | |
| Triple 3-Input Buffered NAND Gate | 4023BM | | | | X | | | | | |
| Triple 3-Input NAND Gate | 4025C | | | | X | | | | | |
| Triple 3-Input NAND Gate | 4025M | | | | X | | | | | |
| Triple 3-Input Buffered NOR Gate | 4025BC | | | | X | | | | | |
| Triple 3-Input Buffered NOR Gate | 4025BM | | | | X | | | | | |
| Quad Exclusive-OR Gate | 4030C | | | | X | | | | | |
| Quad Exclusive-OR Gate | 4030M | | | | X | | | | | |
| Quad True/Complement Buffer | 4041C | | | | X | | | | | |
| Quad True/Complement Buffer | 4041M | | | | X | | | | | |
| TRI-STATE Expandable 8-Function 8-Input Gate | 4048BC | | | | X | | | | | |
| TRI-STATE Expandable 8-Function 8-Input Gate | 4048BM | | | | X | | | | | |
| Hex Inverting Logic Level Down Converter | 4049 | | | | | X | | | | |
| Hex Logic Level Down Converter | 4050 | | | | | X | | | | |
| Inverter Circuit | 4069UBM | | | | X | | | | | |
| Inverter Circuit | 4069UBC | | | | X | | | | | |
| Quad 2-Input Exclusive-OR Gate | 4070BC | | | | X | | | | | |
| Quad 2-Input Exclusive-OR Gate | 4070BM | | | | X | | | | | |
| Quad 2-Input OR Buffered B Series Gate | 4071BC | | | | X | | | | | |
| Quad 2-Input OR Buffered B Series Gate | 4071BM | | | | X | | | | | |
| Double Buffered Triple 3-Input AND Gate | 4073BC | | | | X | | | | | |
| Double Buffered Triple 3-Input AND Gate | 4073BM | | | | X | | | | | |
| Triple 3-Input OR Gate | 4075 | | | | | X | | | | |

## Gates/Inverters (Continued)

| | | (Logic Families) Technology | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
| Double Buffered Triple 3-Input OR Gate | 4075BC | | | | X | | | | | |
| Double Buffered Triple 3-Input OR Gate | 4075BM | | | | X | | | | | |
| 8-Input NOR/OR Gate | 4078 | | | | | X | | | | |
| Quad 2-Input AND Buffered B Series Gate | 4081BC | | | | X | | | | | |
| Quad 2-Input AND Buffered B Series Gate | 3081BM | | | | X | | | | | |
| 4-Bit AND/OR Selector | 4519BC | | | | X | | | | | |
| 4-Bit AND/OR Selector | 4519BM | | | | X | | | | | |

## Latches

| | | (Logic Families) Technology | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
| 4-Bit Bistable Latch with Q and $\overline{Q}$ Output | 75 | | | | | X | | X | | X |
| 8-Bit Serial In to Parallel Out Addressable Latch | 259 | | | | | X | | X | | X |
| Quad S-R Latch | 279 | | | | | | | X | | |
| Octal TRI-STATE Transparent D Latch | 373 | X | X | X | | X | X | X | X | |
| Octal TRI-STATE Inverting Transparent D Latch | 533 | X | X | | | X | X | | | |
| Octal TRI-STATE Transparent D Latch | 563 | X | | | | X | X | | | |
| Octal TRI-STATE Inverting Transparent D Latch | 573 | X | X | | | X | X | | | |
| Octal TRI-STATE Inverting Transparent D Latch | 580 | X | X | | | | | | | |
| Dual TRI-STATE 4-Bit Transparent D Latch | 873 | X | X | | | | | | | |
| Dual 4-Bit Inverting Transparent D Latch | 880 | X | X | | | | | | | |
| 8-Bit Addressable Latch | 8334 | | | | | | | | | X |
| 8-Bit Addressable Latch | 9334 | | | | | | | | | X |

## Multiplexers/Demultiplexers

| Description | Device Number | (Logic Families) Technology<br>ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
|---|---|---|---|---|---|---|---|---|---|---|
| TRI-STATE 16-Line to 1-Line Multiplexer | 19 | | | X | | | | | | |
| 16-Line to 1-Line Multiplexer | 150 | | | X | | | | | | X |
| 8-Channel Digital Multiplexer | 151 | X | | X | | X | | X | X | |
| 1-of-8 Line Data Selector/Multiplexer | 151A | | | | | | | | | X |
| Dual 4-Input Multiplexer | 153 | X | | | | X | | X | X | X |
| Quad 2-Input Multiplexer | 157 | X | X | X | | X | X | X | X | X |
| Quad 2-Input Multiplexer (Inverted Output) | 158 | X | X | | | X | X | X | X | |
| 8-Channel TRI-STATE Multiplexer | 251 | X | | | | X | | X | X | |
| Dual 4-Channel TRI-STATE Multiplexer | 253 | X | | | | X | | X | X | |
| Quad TRI-STATE 2-to-1 Line Data Selector/Multiplexer | 257 | X | X | | | X | X | | X | |
| Quad TRI-STATE 2-to-1 Line Data Selector/Multiplexer | 257B | | | | | | | X | | |
| Quad TRI-STATE 2-to-1 Line Inverting Data Selector/Multiplexer | 258 | X | X | | | | | | X | |
| Quad TRI-STATE 2-to-1 Line Inverting Data Selector/Multiplexer | 258B | | | | | | | X | | |
| Quad 2-Input Multiplexer with Storage | 298 | | | | | X | | | | |
| Dual 1 of 4 Line Inverting Data Selector/Multiplexer | 352 | X | | | | | | X | | |
| Dual TRI-STATE 1 of 4 Line Data Selector/Multiplexer | 353 | X | | | | | | | | |
| 8-Channel TRI-STATE Multiplexer with Latches | 354 | | | | | X | | | | |
| 8-Channel TRI-STATE Multiplexer with Latches | 356 | | | | | X | | | | |
| Quad Bilateral Switch | 4016BC | | | | X | | | | | |
| Quad Bilateral Switch | 4016BM | | | | X | | | | | |
| Analog Multiplexer/Demultiplexer | 4051BC | | | | X | | | | | |
| Analog Multiplexer/Demultiplexer | 4051BM | | | | X | | | | | |
| Analog Multiplexer/Demultiplexer | 4052BC | | | | X | | | | | |
| Analog Multiplexer/Demultiplexer | 4052BM | | | | X | | | | | |
| Analog Multiplexer/Demultiplexer | 4053BC | | | | X | | | | | |
| Analog Multiplexer/Demultiplexer | 4053BM | | | | X | | | | | |
| Quad Bilateral Switch | 4066BC | | | | X | | | | | |
| Quad Bilateral Switch | 4066BM | | | | X | | | | | |
| 8-Channel Data Selector | 4512BC | | | | X | | | | | |
| 8-Channel Data Selector | 4512BM | | | | X | | | | | |
| Dual 4-Channel or Single 8-Channel Analog Data Selector | 4529BC | | | | X | | | | | |
| Dual 4-Channel or Single 8-Channel Analog Data Selector | 4529BM | | | | X | | | | | |
| Quad TRI-STATE 1-of-2 Line Data Selector/Multiplexer | 7123 | | | | | | | | | X |
| Quad TRI-STATE 1-of-2 Line Data Selector/Multiplexer | 8123 | | | | | | | | | X |
| 1-of-8 Line Data Selector/Multiplexer | 8312 | | | | | | | | | X |
| Quad 1-of-2 Line Data Selector/Multiplexer | 8322 | | | | | | | | | X |
| Dual 1-of-4 Line Data Selector/Multiplexer with Complementary Outputs | 9312 | | | | | | | | | X |
| Quad 1-of-2 Line Data Selector/Multiplexer | 9322 | | | | | | | | | X |

## Multivibrators

| Description | Device Number | (Logic Families) Technology | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
| Monostable Multivibrator with Schmitt-Trigger Input | 121 | | | | | | | | | X |
| Retriggerable Monostable Multivibrator with Clear | 122 | | | | | | | X | | |
| Dual Retriggerable Monostable Multivibrator with Clear | 123 | | | | | X | | X | | X |
| Dual Monostable Multivibrator | 221 | | | X | | X | | X | | |
| Dual Retriggerable Monostable Multivibrator | 423A | | | | | | | | | X |
| Phase Comparator | 932 | | | X | | | | | | |
| CMOS Phase-Lock-Loop | 4046 | | | | X | X | | | | |
| Low Power Monostable/Astable Multivibrator | 4047 | | | | X | | | | | |
| Dual Monostable Multivibrator | 4528BC | | | | X | | | | | |
| Dual Monostable Multivibrator | 4528BM | | | | X | | | | | |
| Dual Retriggerable Monostable Multivibrator | 4538 | | | | X | | | | | |
| Dual Monostable Multivibrator | 4538BC | | | | X | | | | | |
| Dual Monostable Multivibrator | 4538BM | | | | X | | | | | |
| Programmable Timer with Oscillator | 4541BC | | | | X | | | | | |
| Programmable Timer with Oscillator | 4541BM | | | | X | | | | | |
| Retriggerable Monostable Multivibrator with Complementary Outputs | 8601 | | | | | | | | | X |
| Dual Retriggerable, Resettable Monostable Multivibrator with Complementary Outputs | 8602 | | | | | | | | | X |
| Retriggerable Monostable Multivibrator with Complementary Outputs | 9601 | | | | | | | | | X |
| Dual Retriggerable, Resettable Monostable Multivibrator with Complementary Outputs | 9602 | | | | | | | | | X |

# Registers

| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (Logic Families) Technology | | | | | | | | |
| 4-Bit Parallel Access Shift Register | 95 | | | X | | | | | | X |
| 8-Bit Serial In/Parallel Out Shift Register with Asynchronous Clear | 164 | | | X | | X | X | X | | X |
| 8-Bit Parallel In/Serial Out Shift Register with Complementary Outputs | 165 | X | | X | | X | | X | | |
| 8-Bit Parallel or Serial In/Serial Out Shift Register with Complementary Outputs | 166 | X | | | | | | X | | X |
| 4-Bit TRI-STATE Register | 173 | | | | | | | | | X |
| 4-Bit TRI-STATE Register | 173A | | | | | | | X | | |
| 4-Bit Bidirectional Universal Shift Register | 194 | | | | | X | | | X | X |
| 4-Bit Bidirectional Universal Shift Register | 194A | | | | | | | X | | |
| 4-Bit Parallel Access Shift Register | 195 | | | X | | X | | X | X | |
| 4-Bit Parallel Access Shift Register | 299 | | | | | X | X | | X | |
| 8-Bit TRI-STATE Universal Shift Register | 323 | | | | | | X | | | |
| 8-Bit Shift Register with Input Latches and TRI-STATE Serial Output | 589 | | | | | X | | | | |
| 8-Bit Shift Register with Output Latches | 595 | | | | | X | | | | |
| 8-Bit Shift Register with Input Latches | 597 | | | | | X | | | | |
| 12-Bit Successive Approximation Register | 905 | | | X | | | | | | |
| 8-Bit Successive Approximation Register | 2502 | | | | | | | | | X |
| 8-Bit Expandable Successive Approximation Register | 2503 | | | | | | | | | X |
| 12-Bit Expandable Successive Approximation Register | 2504 | | | | | | | | | X |
| 18-Stage Static Shift Register | 4006BC | | | | X | | | | | |
| 18-Stage Static Shift Register | 4006BM | | | | X | | | | | |
| 8-Stage Static Shift Register | 4014BC | | | | X | | | | | |
| 8-Stage Static Shift Register | 4014BM | | | | X | | | | | |
| Dual 4-Bit Static Register | 4015BC | | | | X | | | | | |
| Dual 4-Bit Static Register | 4015BM | | | | X | | | | | |
| 8-Stage Static Shift Register | 4021BC | | | | X | | | | | |
| 8-Stage Static Shift Register | 4021BM | | | | X | | | | | |
| 64-Stage Static Shift Register | 4031BC | | | | X | | | | | |
| 64-Stage Static Shift Register | 4031BM | | | | X | | | | | |
| 8-Stage TRI-STATE Bidirectional Parallel/Serial Input/Output Bus Register | 4034BC | | | | X | | | | | |
| 8-Stage TRI-STATE Bidirectional Parallel/Serial Input/Output Bus Register | 4034BM | | | | X | | | | | |
| 4-Bit Parallel-In/Parallel-Out Shift Register | 4035BC | | | | X | | | | | |
| 4-Bit Parallel-In/Parallel-Out Shift Register | 4035BM | | | | X | | | | | |
| 4-Bit Positive-Edge-Triggered Parallel or Serial Access Shift Registers | 8300 | | | | | | | | | X |

## Transceivers

| Description | Device Number | ALS 74 | AS 74 | C 54/74 | CD 4 | HC 54/74 | HCT 54/74 | LS 54/74 | S 54/74 | TTL 54/74 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (Logic Families) Technology | | | | | | | | |
| Inverting Quad TRI-STATE Transceiver | 242 | X | X | | | X | | | | |
| Quad TRI-STATE Transceiver | 243 | X | X | | | X | | X | | |
| Octal TRI-STATE Transceiver | 245 | X | X | | | X | X | X | | |
| Octal TRI-STATE Inverting Bus Transceiver | 620 | X | X | | | | | | | |
| Octal TRI-STATE Inverting Bus Transceiver | 640 | X | X | | | X | X | | | |
| Octal TRI-STATE True and Inverting Bus Transceiver | 643 | X | X | | | X | X | | | |
| Octal TRI-STATE Bus Transceiver | 645 | | | | | | | X | | |
| Octal TRI-STATE Bus Transceiver/Register | 646 | X | X | | | X | | | | |
| Octal TRI-STATE Inverting Bus Transceiver/Register | 648 | X | X | | | X | | | | |
| Octal TRI-STATE Inverting Bus Transceiver/Register | 651 | | X | | | | | | | |
| Octal TRI-STATE Bus Transceiver/Register | 652 | X | X | | | | | | | |
| Quad TRI-STATE Inverting Bus Transceiver | 1242 | X | | | | | | | | |
| Quad TRI-STATE Bus Transceiver | 1243 | X | | | | | | | | |
| Octal Bus Transceiver with Open-Collector and TRI-STATE Outputs | 1639 | | | | | | | | | |
| Octal TRI-STATE True and Inverting Bus Transceiver | 1643 | | | | | | | | | |
| Octal TRI-STATE Inverting Bus Transceiver/MOS Driver | 2620 | | X | | | | | | | |
| Transceiver/MOS Driver | 2645 | | X | | | | | | | |

# Memory

For additional Memory products, see pages 311 and 437.

# Memory

## National Semiconductor Looks at Memory the Way You Do.

Some systems require non-volatile memory with lightning-fast address-access times for high-speed microcontrol storage. To meet those needs, there is National's Bipolar PROM Family.

Our CMOS EPROM family is for systems that require non-volatile memory with low power consumption, reprogrammability, and microprocessor speeds.

For applications where in-circuit, remote-programmable memory will promote design flexibility and end product advantage, National provides you with a family of EEPROMs.

For high performance, National's families of TTL and high-speed MOS static RAMs are designed to meet your system-design requirements for speed and density. ECL is the best choice for ultra-high performance. From the 7 ns access time of our ECL RAMs, to the 256 k-bit density in our high-speed CMOS static RAMs, National has a solution to your RAM needs.

All National RAMs are designed for the military environment.

## CMOS EPROMs

The largest family of CMOS EPROMs available worldwide was designed to meet your current and future system requirements in density, speed, and power consumption. Using the latest microCMOS technology with down to 1.5-micron feature sizes, National provides the best cost/performance combination in the industry.

Programming algorithms are installed in all major PROM programmer equipment and ease of programming is enhanced via our manufacturer's identification code.

| Device Numbers | Organization | Size | Access Time | Prog Volt | PS Total | Power (mW) Active/Standby | Temp Range (°C) | Packaging Information |
|---|---|---|---|---|---|---|---|---|
| NMC27C16BQ35 | 2k × 8 | 16k | 350 | 13 | 5% | 26.25/0.53 | 0 to + 70 | Q24A |
| NMC27C16BQE35 | 2k × 8 | 16k | 350 | 13 | 5% | 26.25/0.53 | – 40 to + 85 | Q24A |
| NMC27C32BQ200 | 4k × 8 | 32k | 200 | 13 | 10% | 27.5/0.55 | 0 to + 70 | Q24A |
| NMC27C32BQ350 | 4k × 8 | 32k | 350 | 13 | 10% | 27.5/0.55 | 0 to + 70 | Q24A |
| NMC27C32BQE200 | 4k × 8 | 32k | 200 | 13 | 10% | 27.5/0.55 | – 40 to + 85 | Q24A |
| NMC27C32BQE350 | 4k × 8 | 32k | 350 | 13 | 10% | 27.5/0.55 | – 40 to + 85 | Q24A |
| NMC27C64Q15 | 8k × 8 | 64k | 150 | 13 | 5% | 55/0.55 | 0 to + 70 | Q28A |
| NMC27C64Q150 | 8k × 8 | 64k | 150 | 13 | 10% | 55/0.55 | 0 to + 70 | Q28A |
| NMC27C64Q200 | 8k × 8 | 64k | 200 | 13 | 10% | 55/0.55 | 0 to + 70 | Q28A |
| NMC27C64Q250 | 8k × 8 | 64k | 250 | 13 | 10% | 55/0.55 | 0 to + 70 | Q28A |
| NMC27C64Q300 | 8k × 8 | 64k | 300 | 13 | 10% | 55/0.55 | 0 to + 70 | Q28A |
| NMC27C64QE200 | 8k × 8 | 64k | 200 | 13 | 10% | 55/0.55 | – 40 to + 85 | Q28A |
| NMC27C64QM250 | 8k × 8 | 64k | 250 | 13 | 10% | 55/0.55 | – 55 to + 125 | Q28A |
| NMC27C256Q17 | 32k × 8 | 256k | 170 | 13 | 5% | 55/0.55 | 0 to + 70 | Q28A |
| NMC27C256Q200 | 32k × 8 | 256k | 200 | 13 | 10% | 55/0.55 | 0 to + 70 | Q28A |
| NMC27C256Q250 | 32k × 8 | 256k | 250 | 13 | 10% | 55/0.55 | 0 to + 70 | Q28A |
| NMC27C256Q300 | 32k × 8 | 256k | 300 | 13 | 10% | 55/0.55 | 0 to + 70 | Q28A |
| NMC27C256QE250 | 32k × 8 | 256k | 250 | 13 | 10% | 55/0.55 | – 40 to + 85 | Q28A |
| NMC27C256QM250 | 32k × 8 | 256k | 250 | 13 | 10% | 55/0.55 | – 55 to + 125 | Q28A |
| NMC27C256QM350 | 32k × 8 | 256k | 350 | 13 | 10% | 55/0.55 | – 55 to + 125 | Q28A |
| NMC27C256BQ90 | 32k × 8 | 256k | 90 | 12.5 | 10% | 220/0.55 | 0 to + 70 | Q28A |
| NMC27C256BQ120 | 32k × 8 | 256k | 120 | 12.5 | 10% | 220/0.55 | 0 to + 70 | Q28A |
| NMC27C256BQ150 | 32k × 8 | 256k | 150 | 12.5 | 10% | 220/0.55 | 0 to + 70 | Q28A |
| NMC27C256BQ200 | 32k × 8 | 256k | 200 | 12.5 | 10% | 220/0.55 | 0 to + 70 | Q28A |
| NMC27C256BQE120 | 32k × 8 | 256k | 120 | 12.5 | 10% | 220/0.55 | – 40 to + 85 | Q28A |
| NMC27C256BQM150 | 32k × 8 | 256k | 150 | 12.5 | 10% | 220/0.55 | – 55 to + 125 | Q28A |
| NMC27C512Q20 | 64k × 8 | 512k | 200 | 13 | 5% | 55/0.55 | 0 to + 70 | Q28A |
| NMC27C512Q250 | 64k × 8 | 512k | 250 | 13 | 10% | 55/0.55 | 0 to + 70 | Q28A |
| NMC27C512Q300 | 64k × 8 | 512k | 300 | 13 | 10% | 55/0.55 | 0 to + 70 | Q28A |
| NMC27C512Q350 | 64k × 8 | 512k | 350 | 13 | 10% | 55/0.55 | 0 to + 70 | Q28A |
| NMC27C512QE250 | 64k × 8 | 512k | 250 | 13 | 10% | 55/0.55 | – 40 to + 85 | Q28A |
| NMC27C512QM350 | 64k × 8 | 512k | 350 | 13 | 10% | 55/0.55 | – 55 to + 125 | Q28A |
| NMC27C512AQ90 | 64k × 8 | 512k | 90 | 12.5 | 10% | 220/0.55 | 0 to + 70 | Q28A |
| NMC27C512AQ120 | 64k × 8 | 512k | 120 | 12.5 | 10% | 220/0.55 | 0 to + 70 | Q28A |
| NMC27C512AQ150 | 64k × 8 | 512k | 150 | 12.5 | 10% | 220/0.55 | 0 to + 70 | Q28A |
| NMC27C512AQ200 | 64k × 8 | 512k | 200 | 12.5 | 10% | 220/0.55 | 0 to + 70 | Q28A |
| NMC27C512AQE120 | 64k × 8 | 512k | 120 | 12.5 | 10% | 220/0.55 | – 40 to + 85 | Q28A |
| NMC27C512AQM150 | 64k × 8 | 512k | 150 | 12.5 | 10% | 220/0.55 | – 55 to + 125 | Q28A |

## CMOS EPROMs (Continued)

| Device Numbers | Organization | Size | Access Time | Prog Volt | PS Total | Power (mW) Active/Standby | Temp Range (°C) | Packaging Information |
|---|---|---|---|---|---|---|---|---|
| NMC27C1024Q90 | 64k × 16 | 1024k | 90 | 12.5 | 10% | 275/0.55 | 0 to + 70 | Q40A |
| NMC27C1024Q120 | 64k × 16 | 1024k | 120 | 12.5 | 10% | 275/0.55 | 0 to + 70 | Q40A |
| NMC27C1024Q150 | 64k × 16 | 1024k | 150 | 12.5 | 10% | 275/0.55 | 0 to + 70 | Q40A |
| NMC27C1024Q200 | 64k × 16 | 1024k | 200 | 12.5 | 10% | 275/0.55 | 0 to + 70 | Q40A |
| NMC27C1024QE120 | 64k × 16 | 1024k | 120 | 12.5 | 10% | 275/0.55 | − 40 to + 85 | Q40A |
| NMC27C1024QM150 | 64k × 16 | 1024k | 150 | 12.5 | 10% | 275/0.55 | − 55 to + 125 | Q40A |
| NMC27C1023Q90 | 128k × 8 | 1024k | 90 | 12.5 | 10% | 275/0.55 | 0 to + 70 | Q32A |
| NMC27C1023Q120 | 128k × 8 | 1024k | 120 | 12.5 | 10% | 275/0.55 | 0 to + 70 | Q32A |
| NMC27C1023Q150 | 128k × 8 | 1024k | 150 | 12.5 | 10% | 275/0.55 | 0 to + 70 | Q32A |
| NMC27C1023Q200 | 128k × 8 | 1024k | 200 | 12.5 | 10% | 275/0.55 | 0 to + 70 | Q32A |
| NMC27C1023QE120 | 128k × 8 | 1024k | 120 | 12.5 | 10% | 275/0.55 | − 40 to + 85 | Q32A |
| NMC27C1023QM150 | 128k × 8 | 1024k | 150 | 12.5 | 10% | 275/0.55 | − 55 to + 125 | Q32A |

## EEPROMs

National EEPROMs expand your design flexibility for systems needing in-circuit and/or remote programming, as the advanced floating gate technology permits both writing and erasing electrically. Designing with EEPROMs not only enhances your product benefits, but will also replace devices such as mechanical dip switches, battery back-up RAM and potentiometers, increasing your overall product reliability and decreasing your product cost. National offers both NMOS and CMOS families of EEPROMs.

| Device Number | Organization | Size | Packaging Information | Interface | Power Consumption Active/Standby | Temp Range (°C) |
|---|---|---|---|---|---|---|
| NMC9306 | 16 × 16 | 256-bit | N08E, M14B, M08A | Serial | 10 mA/3 mA | 0 to + 70 |
| NMC9306E | 16 × 16 | 256-bit | N08E | Serial | 12 mA/4 mA | − 40 to + 85 |
| NMC9306M | 16 × 16 | 256-bit | N08E | Serial | 14 mA/5 mA | − 55 to + 125 |
| NMC9307 | 16 × 16 | 256-bit | N08E | Serial | 10 mA/3 mA | 0 to + 70 |
| NMC9307E | 16 × 16 | 256-bit | N08E | Serial | 12 mA/4 mA | − 40 to + 85 |
| NMC9313B | 16 × 16 | 256-bit | N08E | Serial | 12 mA/4 mA | 0 to + 70 |
| NMC9346 | 64 × 16 | 1024 | N08E, M14B, M08A | Serial | 12 mA/3 mA | 0 to + 70 |
| NMC9346E | 64 × 16 | 1024 | N08E | Serial | 14 mA/4 mA | − 40 to + 85 |
| NMC9346M | 64 × 16 | 1024 | N08E | Serial | 12 mA/3 mA | − 55 to + 125 |
| NMC9314B | 64 × 16 | 1024 | N08E | Serial | 14 mA/4 mA | 0 to + 70 |
| NMC93CS06 | 16 × 16 | 256 | N08E, M14B | Serial | 2.5 mA/100 mA | − 55 to + 125 |
| NMC93CS26 | 32 × 16 | 512 | N08E, M14B | Serial | 5 mA/0.2 mA | − 55 to + 125 |
| NMC93CS46 | 64 × 16 | 1024 | N08E, M14B | Serial | 5 mA/0.2 mA | − 55 to + 125 |
| NMC93CS56 | 128 × 16 | 2048 | N08E, M14B | Serial | 3 mA/50 mA | − 55 to + 125 |
| NMC93CS66 | 256 × 16 | 4096 | N08E, M14B | Serial | 3 mA/50 mA | − 55 to + 125 |
| NMC98C10 | 128 × 8 | 1024 | N18A | Mux | 10 mA/100 mA | 0 to + 70 |
| NMC98C40 | 512 × 8 | 4096 | N18A | Mux | 10 mA/100 mA | 0 to + 70 |

## Bipolar PROMs

High-speed microcontrol storage is made practical at very low cost through the use of National's bipolar PROMs. This generic family utilizes the latest in Schottky circuitry and titanium-tungsten fuse link technology.

National offers these and other memory and logic products for state-of-the-art solutions to data processing and control logic design problems.

| Size (Bits) | Organization | Commercial Part Number | $t_{AA}$ Commercial (Max) in ns | $t_{AA}$ Mil Temp (Max) in ns | $I_{CC}$ (Max) in A | Description | Temp Range (°C) | Package Type |
|---|---|---|---|---|---|---|---|---|
| 256 | 32 × 8 OC | DM74S188 | 35 | 45 | 110 | (32 × 8) 256-Bit TTL PROM | 0 to + 70 | J, N16A |
| | 32 × 8 OC | DM74S188A | 25 | 20 | 110 | (32 × 8) 256-Bit TTL PROM | 0 to + 70 | J, N16A |
| | 32 × 8 TS | DM74S288 | 35 | 45 | 110 | (32 × 8) 256-Bit TTL PROM | 0 to + 70 | J, N16A |
| | 32 × 8 TS | DM74S288A | 25 | 20 | 110 | (32 × 8) 256-Bit TTL PROM | 0 to + 70 | J, N16A |
| | 32 × 8 TS | PL87X288B | 15 | 12 | 140 | (32 × 8) 256-Bit TTL PROM | 0 to + 70 | J, N16A |
| 1024 | 256 × 4 OC | DM74S387 | 50 | 60 | 130 | (256 × 4) 1024-Bit TTL PROM | 0 to + 70 | J, N16A |
| | 256 × 4 OC | DM74S387A | 30 | 20 | 130 | (256 × 4) 1024-Bit TTL PROM | 0 to + 70 | J, N16A |
| | 256 × 4 TS | DM74S287 | 50 | 60 | 130 | (256 × 4) 1024-Bit TTL PROM | 0 to + 70 | J, N16A |
| | 256 × 4 TS | DM74S287A | 30 | 20 | 130 | (256 × 4) 1024-Bit TTL PROM | 0 to + 70 | J, N16A |
| 2048 | 512 × 4 OC | DM74S570 | 55 | 65 | 130 | (512 × 4) 2048-Bit TTL PROM | 0 to + 70 | J, N16A |
| | 512 × 4 TS | DM74S571 | 55 | 65 | 130 | (512 × 4) 2048-Bit TTL PROM | 0 to + 70 | J, N16A |
| | 512 × 4 OC | DM74S570A | 45 | 60 | 130 | (512 × 4) 2048-Bit TTL PROM | 0 to + 70 | J, N16A |
| | 512 × 4 TS | DM74S571A | 45 | 60 | 130 | (512 × 4) 2048-Bit TTL PROM | 0 to + 70 | J, N16A |
| | 512 × 4 TS | DM74S571B | 35 | 50 | 130 | (512 × 4) 2048-Bit TTL PROM | 0 to + 70 | J, N16A |
| 2048 | 256 × 8 TS | DM74LS471 | 60 | 70 | 100 | (256 × 8) 2048-Bit TTL PROM | 0 to + 70 | J20B, N20A |
| 4096 | 512 × 8 OC | DM74S475 | 65 | 75 | 170 | (512 × 8) 4096-Bit TTL PROM | 0 to + 70 | J, N24A |
| | 512 × 8 TS | DM74S474 | 65 | 75 | 170 | (512 × 8) 4096-Bit TTL PROM | 0 to + 70 | J, N24A |
| | 512 × 8 OC | DM74S475A | 45 | 60 | 170 | (512 × 8) 4096-Bit TTL PROM | 0 to + 70 | J, N24A |
| | 512 × 8 TS | DM74S474A | 45 | 60 | 170 | (512 × 8) 4096-Bit TTL PROM | 0 to + 70 | J, N24A |
| | 512 × 8 TS | DM74S474B | 35 | 50 | 170 | (512 × 8) 4096-Bit TTL PROM | 0 to + 70 | J, N24A |
| 4096 | 512 × 8 OC | DM74S473 | 60 | 75 | 155 | (512 × 8) 4096-Bit TTL PROM | 0 to + 70 | J20B, N20A |
| | 512 × 8 TS | DM74S472 | 60 | 75 | 155 | (512 × 8) 4096-Bit TTL PROM | 0 to + 70 | J20B, N20A |
| | 512 × 8 OC | DM74S473A | 45 | 60 | 155 | (512 × 8) 4096-Bit TTL PROM | 0 to + 70 | J20B, N20A |
| | 512 × 8 TS | DM74S472A | 45 | 60 | 155 | (512 × 8) 4096-Bit TTL PROM | 0 to + 70 | J20B, N20A |
| | 512 × 8 TS | DM74S472B | 35 | 50 | 155 | (512 × 8) 4096-Bit TTL PROM | 0 to + 70 | J20B, N20A |
| 4096 | 1024 × 4 OC | DM74S572 | 60 | 75 | 140 | (1024 × 4) 4096-Bit TTL PROM | 0 to + 70 | J18A, N18A |
| | 1024 × 4 TS | DM74S573 | 60 | 75 | 140 | (1024 × 4) 4096-Bit TTL PROM | 0 to + 70 | J18A, N18A |
| | 1024 × 4 OC | DM74S572A | 45 | 60 | 140 | (1024 × 4) 4096-Bit TTL PROM | 0 to + 70 | J18A, N18A |
| | 1024 × 4 TS | DM74S573A | 45 | 60 | 140 | (1024 × 4) 4096-Bit TTL PROM | 0 to + 70 | J18A, N18A |
| | 1024 × 4 TS | DM74S573B | 35 | 55 | 140 | (1024 × 4) 4096-Bit TTL PROM | 0 to + 70 | J18A, N18A |
| 8192 | 1024 × 8 OC | DM87S180 | 55 | 75 | 170 | (1024 × 8) 8192-Bit TTL PROM | 0 to + 70 | J24A, N24A |
| | 1024 × 8 TS | DM87S181 | 55 | 75 | 170 | (1024 × 8) 8192-Bit TTL PROM | 0 to + 70 | J24A, N24A |

## Bipolar PROMs (Continued)

| Size (Bits) | Organization | Commercial Part Number | $t_{AA}$ Commercial (Max) in ns | $t_{AA}$ Mil Temp (Max) in ns | $I_{CC}$ (Max) in A | Description | Temp Range*** (°C) | Package Type |
|---|---|---|---|---|---|---|---|---|
| 8192 | 2048 × 4 OC | DM87S184 | 55 | 70 | 140 | (2048 × 4) 8192-Bit TTL PROM | 0 to + 70 | J18A, N18A |
| | 2048 × 4 TS | DM87S185 | 55 | 70 | 140 | (2048 × 4) 8192-Bit TTL PROM | 0 to + 70 | J18A, N18A |
| | 2048 × 4 OC | DM87S184A | 45 | 60 | 140 | (2048 × 4) 8192-Bit TTL PROM | 0 to + 70 | J18A, N18A |
| | 2048 × 4 TS | DM87S185A | 45 | 60 | 140 | (2048 × 4) 8192-Bit TTL PROM | 0 to + 70 | J18A, N18A |
| | 2048 × 4 TS | DM87S185B | 35 | 50 | 140 | (2048 × 4) 8192-Bit TTL PROM | 0 to + 70 | J18A, N18A |
| 8192 | 1024 × 8 OC | DM87S280 | 55 | 75 | 170 | (1024 × 8) 8192-Bit TTL PROM | 0 to + 70 | J24C, N24C |
| | 1024 × 8 TS | DM87S281 | 55 | 75 | 170 | (1024 × 8) 8192-Bit TTL PROM | 0 to + 70 | J24C, N24C |
| | 1024 × 8 TS | DM87S281A | 45 | 65 | 170 | (1024 × 8) 8192-Bit TTL PROM | 0 to + 70 | J24C, N24C |
| 16384 | 2048 × 8 OC | DM87S190 | 65 | 80 | 175 | (2048 × 8) 16,384-Bit TTL PROM | 0 to + 70 | J24C, N24C |
| | 2048 × 8 TS | DM87S191 | 65 | 80 | 175 | (2048 × 8) 16,384-Bit TTL PROM | 0 to + 70 | J24C, N24C |
| | 2048 × 8 TS | DM87S191A | 45 | 60 | 175 | (2048 × 8) 16,384-Bit TTL PROM | 0 to + 70 | J24C, N24C |
| | 2048 × 8 TS | DM87S191B | 35 | 50 | 175 | (2048 × 8) 16,384-Bit TTL PROM | 0 to + 70 | J24C, N24C |
| 16384 | 2048 × 8 OC | *DM87S290 | 65 | 80 | 175 | (2048 × 8) 16,384-Bit TTL PROM | 0 to + 70 | J24C, N24C |
| | 2048 × 8 TS | *DM87S291 | 65 | 80 | 175 | (2048 × 8) 16,384-Bit TTL PROM | 0 to + 70 | J24C, N24C |
| | 2048 × 8 TS | *DM87S291A | 45 | 60 | 175 | (2048 × 8) 16,384-Bit TTL PROM | 0 to + 70 | J24C, N24C |
| | 2048 × 8 TS | *DM87S291B | 35 | 50 | 175 | (2048 × 8) 16,384-Bit TTL PROM | 0 to + 70 | J24C, N24C |
| 16384 | 4096 × 4 TS | DM87S195A | 45 | 60 | 170 | (4096 × 4) 16,384-Bit TTL PROM | 0 to + 70 | J20B, N20A |
| | 4096 × 4 TS | DM87S195B | 35 | 50 | 170 | (4096 × 4) 16,384-Bit TTL PROM | 0 to + 70 | J20B, N20A |
| 32768 | 4096 × 8 TS | DM87S321 | 55 | 65 | 185 | (4096 × 8) 32,768-Bit TTL PROM | 0 to + 70 | N24C |
| | 4096 × 8 TS | *DM87S421 | 55 | 65 | 185 | (4096 × 8) 32,768-Bit TTL PROM | 0 to + 70 | N24C |

## Registered PROMs

| Size (Bits) | Organization | Commercial Part Number | Set Up | Clk to Out | Set Up | Clk to Out | $I_{CC}$ (Max) in A | Temp Range (°C) | Package Type |
|---|---|---|---|---|---|---|---|---|---|
| 4096 | 512 × 8 TS | DM87SR25 | 35 | 20 | 40 | 25 | 185 | 0 to + 70 | J20B, N20A |
| | 512 × 8 TS | DM87SR476 | 35 | 20 | 40 | 25 | 185 | 0 to + 70 | J20B, N20A |
| | 512 × 8 TS | DM87SR474 | 35 | 20 | 40 | 25 | 185 | 0 to + 70 | J20B, N20A |
| 4096 | 512 × 8 REG | DM87SR474B | 35 | 20 | 40 | 25 | | 0 to + 70 | J20B, N20A |
| | 512 × 8 REG | DM87SR476B | 35 | 20 | 40 | 25 | | 0 to + 70 | J20B, N20A |
| | 512 × 8 REG | DM87SR25B | 35 | 20 | 40 | 25 | | 0 to + 70 | J20B, N20A |
| 8192 | 1024 × 8 TS | DM87SR181 | 40 | 20 | 50 | 30 | 175 | 0 to + 70 | J24C, N24C |
| | 1024 × 8 REG | DM87SR183 | 40 | 25 | 45 | 30 | | 0 to + 70 | J24C, N24C |
| | 1024 × 8 REG | DM87SR183B | 35 | 20 | 40 | 25 | | 0 to + 70 | J24C, N24C |
| 16384 | 2048 × 4 REG | DM87SR191** | 25 | 10 | 30 | 15 | | 0 to + 70 | J20B, N20A |
| | 2048 × 4 REG | DM87SR193** | 25 | 10 | 30 | 15 | | 0 to + 70 | J20B, N20A |

Note: To specify military temperature range devices, convert 74SXXX numbers to 54SXXX and 87SXXX numbers to 77SXXX.

* Indicates 0.3″ wide package.

** To be released.

*** Commercial range; military range is − 55 to + 125°C.

## High-Speed Static RAMs

For systems requiring fast access time National Semiconductor offers high-speed, low power static RAMs from 4k to 256k densities. For higher densities, National uses its 1.5-micron technology to achieve speeds as low as 35 ns.

| Device Number | Organization | Size | Packaging | Access | Power (mW) |
|---|---|---|---|---|---|
| NMC2147HN-1 | 4k × 1 | 4k | N18A | 35 | 990/165 |
| NMC2147HJ-1 | 4k × 1 | 4k | J18A | 35 | 990/165 |
| NMC2147HN-2 | 4k × 1 | 4k | N18A | 45 | 990/165 |
| NMC2147HJ-2 | 4k × 1 | 4k | J18A | 45 | 990/165 |
| NMC2147HN-3 | 4k × 1 | 4k | N18A | 55 | 990/165 |
| NMC2147HJ-3 | 4k × 1 | 4k | J18A | 55 | 990/165 |
| NMC2147HN-3L | 4k × 1 | 4k | N18A | 55 | 688/110 |
| NMC2147HJ-3L | 4k × 1 | 4k | J18A | 55 | 688/110 |
| NMC2147HN | 4k × 1 | 4k | N18A | 70 | 880/110 |
| NMC2147HJ | 4k × 1 | 4k | J18A | 70 | 880/110 |
| NMC2148HN-2 | 1k × 4 | 4k | N18A | 45 | 990/165 |
| NMC2148HJ-2 | 1k × 4 | 4k | J18A | 45 | 990/165 |
| NMC2148HN-3 | 1k × 4 | 4k | N18A | 55 | 990/165 |
| NMC2148HJ-3 | 1k × 4 | 4k | J18A | 55 | 990/165 |
| NMC2148HN | 1k × 4 | 4k | N18A | 70 | 990/165 |
| NMC2148HJ | 1k × 4 | 4k | J18A | 70 | 990/165 |
| NMC2148HN-3L | 1k × 4 | 4k | N18A | 55 | 688/110 |
| NMC2148HJ-3L | 1k × 4 | 4k | J18A | 55 | 688/110 |
| NMC2148HN-L | 1k × 4 | 4k | N18A | 70 | 688/110 |
| NMC2148HJ-L | 1k × 4 | 4k | J18A | 70 | 688/110 |
| NMC6164AN-45L | 8k × 8 | 64k | N28B | 45 | 165/0.55 |
| NMC6164AN-45 | 8k × 8 | 64k | N28B | 45 | 165/11 |
| NMC6164AN-55L | 8k × 8 | 64k | N28B | 55 | 165/0.55 |
| NMC6164AN-55 | 8k × 8 | 64k | N28B | 55 | 165/11 |
| NMC6164AN-70L | 8k × 8 | 64k | N28B | 70 | 165/0.55 |
| NMC6164AN-70 | 8k × 8 | 64k | N28B | 70 | 165/11 |
| NMC61256N-55L | 32k × 8 | 256k | N28B | 55 | 165/2.65 |
| NMC61256N-55 | 32k × 8 | 256k | N28B | 55 | 165/11 |
| NMC61256N-70L | 32k × 8 | 256k | N28B | 70 | 165/2.65 |
| NMC61256N-70 | 32k × 8 | 256k | N28B | 70 | 165/11 |
| NMC61256N-100L | 32k × 8 | 256k | N28B | 100 | 165/2.65 |
| NMC61256N-100 | 32k × 8 | 256k | N28B | 100 | 165/11 |

## TTL RAMs

For the specialized applications of scratch-pad memory and register files, National offers a line of low-density, high-speed, 64-bit TTL RAMs. National's TTL RAMs are fabricated with our advanced Schottky and Oxiss process to provide the high performance and reliability your system requires.

| Size (Bits) | Organization | Commercial Part Number | $t_{AA}$ Commercial (Max) in ns | $t_{AA}$ Mil Temp (Max) in ns | $I_{CC}$ (Max) in A | Description | Temp Range (°C) | Package Type |
|---|---|---|---|---|---|---|---|---|
| 64 | 16 × 4 TS | DM74S189A | 35 | 50 | 110 | High-Speed 64-Bit TRI-STATE RAM | 0 to + 70 | J16A, N16E |
| 64 | 16 × 4 TS | DM74S289A | 35 | 50 | 110 | High-Speed 64-Bit Open-Collector | 0 to + 70 | J16A, N16E |
| 64 | 16 × 4 TS | DM85S06 | 35 | 50 | 100 | Open Collector | 0 to + 70 | J16A, N16E |
| 64 | 16 × 4 TS | DM85S07 | 35 | 50 | 100 | TRI-STATE | 0 to + 70 | J16A, N16E |
| 64 | 16 × 4 TS | DM85S07A | 25 | 30 | 100 | High-Speed TRI-STATE Non-Inverting, 64-Bit RAM | 0 to + 70 | J16A, N16E |
| 64 | 16 × 4 TS | DM85S68 | 40 | 55 | 100 | Edge Triggered Register | 0 to + 70 | J18A, N18E |
| 64 | 16 × 4 TS | IDM29705 | 40 | 55 | — | (16 word by 4-Bit Two-Port | 0 to + 70 | J28A |
| 64 | 16 × 4 TS | IDM29705A | 30 | 35 | — | RAM/Register File) | 0 to + 70 | J28A |

## ECL RAMs

In advanced ECL memory, National's DM series delivers speed, low power dissipation, and a wide range of sizes and configurations—all fully compatible with 10KH or 100K series families. From 256 to 4096 bits, with speeds as fast as 7 ns...National has it all.

National's ECL RAMs are produced with our advanced oxide-isolated process on the latest state-of-the-art 5″ fabrication line and offer the highest degree of alpha-particle immunity.

National's reliable ECL memories offer the broadest choice in density, organization, speed, and power to assure you the maximum cost/performance benefits.

| Device Number | Size | Organization | Speed ($T_{Max}$) | $I_{EE}$ (Min) | Temp Range (°C) | Packaging Information |
|---|---|---|---|---|---|---|
| **10K Series** | | | | | | |
| DM10414 | 256-Bit | 256 × 1 | 15 ns | – 150 | 0 to + 75 | J16A |
| DM10414A | | | 10 ns | – 150 | 0 to + 75 | J16A |
| DM10415 | 1k Bits | 1,042 × 1 | 28 ns | – 150 | 0 to + 75 | J16A |
| DM10415A | | | 20 ns | – 150 | 0 to + 75 | J16A |
| DM10422 | | 256 × 4 | 12 ns | – 200 | 0 to + 75 | J24E, W24B |
| DM10422A | | | 10 ns | – 200 | 0 to + 75 | J24E, W24B |
| DM10422A-7 | | | 7 ns | – 200 | 0 to + 75 | J24E, W24B |
| DM10470 | 4k Bits | 4,096× 1 | 25 ns | – 200 | 0 to + 75 | J18A |
| DM10470A | | | 15 ns | – 200 | 0 to + 75 | J18A |
| DM10474 | | 1,024 × 4 | 25 ns | – 220 | 0 to + 75 | J24E, W24B |
| DM10474A | | | 15 ns | – 220 | 0 to + 75 | J24E, W24B |
| DM10474A-10 | | | 10 ns | – 220 | 0 to + 75 | J24E, W24B |
| DM10474A-8 | | | 8 ns | – 220 | 0 to + 75 | J24E, W24B |
| **100K Series** | | | | | | |
| DM100422 | 1k Bits | 256 × 4 | 12 ns | – 200 | 0 to + 85 | J16A, W24B |
| DM100422A | | | 10 ns | – 200 | 0 to + 85 | J16A, W24B |
| DM100422A-7 | | | 7 ns | – 200 | 0 to + 85 | J16A, W24B |
| DM100470 | 4k Bits | 4,096 × 1 | 25 ns | – 200 | 0 to + 85 | J18A |
| DM100470 | | | 15 ns | – 200 | 0 to + 85 | J18A |
| DM100474 | | 1,024 × 4 | 25 ns | – 200 | 0 to + 85 | J24E, W24B |
| DM100474A | | | 15 ns | – 200 | 0 to + 85 | J24E, W24B |
| DM100474A-10 | | | 10 ns | – 200 | 0 to + 85 | |
| DM100474A-8 | | | 8 ns | – 200 | 0 to + 85 | |

## Memory Boards Compatible with Digital Equipment Systems

| System | Description | Features | Memory Capacity |
|---|---|---|---|
| VAX8600<br>VAX8650 | NS865-16MB<br>980010488-16 | On board DIAGNOSTICS<br>DRAM LED Display<br>Socketed DRAMs and a spare DRAM on board<br>On-line/off-line switch and associated LED indicator<br>Lifetime warranty<br>For more information, please<br>call: 1-800-538-8510<br>In CA.: 1-800-345-4006<br>In Canada: 408-721-8081 | 16 megabyte per board<br>128 megabytes per system |
| VAX-11/780<br>VAX-11/785 | NS789-1MB<br>980010090-001 | On-line/off-line switch and associated LED indicator<br>ECC | 1 megabyte per board<br>16 megabytes per system |
|  | NS789-4MB<br>980010090-002 | Socketed DRAMs and a spare DRAM on board<br>1 megabyte and 4 megabyte boards can not be mixed in one system.<br>For more information, please<br>call: 1-800-538-8510<br>In CA.: 1-800-345-4006<br>In Canada: 408-721-8081 | 4 megabytes per board<br>32 megabytes per system |
| VAX-11/725 | NS753-1MB<br>980109464-001 | On-line/off-line switch and associated LED indicator<br>LED indicator of voltage presence | 1 megabyte per board<br>3 megabytes per system |
| VAX-11/730 | NS753-1MB<br>980109464-001 | ECC<br>Socketed DRAMs and a spare DRAM on board | 1 megabyte per board<br>5 megabytes per system |
| VAX-11/750 | NS753-1MB<br>980109464-001 | For more information, please<br>call: 1-800-538-8510<br>In CA.: 1-800-345-4006<br>In Canada: 408-721-8081 | 1 megabyte per board<br>8 megabytes per sytsem |
| MicroVAX II | NS630-1MB<br>980010445-001 | On-line/off-line switch and associated LED indicator<br>Spare DRAM on board | 1 megabyte per board<br>3 megabytes per system |
|  | NS630-2MB<br>980010445-002 | Quad width card<br>Any NS630 (1, 2, 4MB) memory size and NS638 (8MB) can be combined in one system. | 2 megabytes per board<br>5 megabytes per system |
|  | NS630-4MB<br>980010445-004 | For more information, please<br>call: 1-800-538-8510 | 4 megabytes per board<br>9 megabytes per system |
|  | NS638-8MB<br>980010482-008 | In CA.: 1-800-345-4006<br>In Canada: 408-721-8081 | 8 megabytes per board<br>16 megabytes per system |

## Memory Boards Compatible with Digital Equipment Systems

| System | Description | Features | Memory Capacity |
|---|---|---|---|
| MicroVAX I<br>PDP-11/23<br>PDP-11/23 +<br>PDP-11/53<br>PDP-11/73 | NS23C-1MB<br>9800101015-015 | Block mode transfer compatibility<br>Parity error LED indicator<br>DEC compatible CSR<br>Dual width card | 1 megabyte per board<br>4 megabytes per system |
| | NS23C-1/2MB<br>9800101015-016 | | 512 Kbytes per board<br>4 megabytes per system |
| | NS23C-1/4MB<br>9800101015-001 | | 256 Kbytes per board<br>4 megabytes per system |
| | NS23D-2MB<br>980110375-001 | Block mode transfer compatibility<br>Parity error LED indicator<br>DEC compatible CSR<br>Dual width card | 2 megabytes per board<br>4 megabytes per system |
| | NS23S-4MB<br>980110014-011 | Block mode transfer compatibility<br>Parity error LED indicator<br>DEC compatible CSR<br>Quad width card | 4 megabytes per board<br>4 megabytes per system |
| | NS23S-3MB<br>980110014-013 | | 3 megabytes per board<br>4 megabytes per system |
| | NS23S-2MB<br>980110014-015 | Any configuration of any of the above boards can be mixed in any of the above systems. | 2 megabytes per board<br>4 megabytes per system |
| | NS23S-1MB<br>980110014-001 | | 1 megabyte per board<br>4 megabytes per system |
| | | For more information, please<br>Call: 1-800-538-8510<br>In CA.: 1-800-345-4006<br>In Canada: 408-721-8081 | |
| PDP-11/04<br>PDP-11/05<br>PDP-11/10<br>PDP-11/15 | NS11U-1/4MB<br>980109453-007 | On board parity controller and CSR<br>Single voltage operation<br>Spare DRAM on board | 256 Kbytes per board<br>64 Kbytes per system |
| PDP-11/60 | NS11U-1/4MB<br>980109453-007 | Any configuration of NS11U can be mixed in one system. | 256 Kbytes per board<br>256 Kbytes per system |
| PDP-11/34<br>PDP-11/34A<br>PDP-11/35<br>PDP-11/40<br>PDP-11/45<br>PDP-11/50<br>PDP-11/55 | NS11U-1MB<br>980109453-001 | | 1 megabyte per board<br>1 megabyte per system |
| | NS11U-1/2MB<br>980109453-005 | | 512 Kbytes per board<br>1 megabyte per system |
| | NS11U-1/4MB<br>980109453-007 | | 256 Kbytes per board<br>1 megabyte per system |
| PDP-11/24<br>PDP-11/44 | NS11U-1MB<br>980109453-001 | | 1 megabyte per board<br>4 megabytes per system |
| | NS11U-1/2MB<br>980109453-005 | | 512 Kbytes per board<br>2 megabytes per system |
| | NS11U-1/4MB<br>980109453-007 | | 256 Kbytes per board<br>1 megabyte per system |
| | | For more information, please<br>call: 1-800-538-8510<br>In CA.: 1-800-345-4006<br>In Canada: 408-721-8081 | |

# Microcontrollers

For additional Microcontroller products, see page 441.

## Microcontrollers for Today and Tomorrow

Our microcontroller families provide a complete range of performance and features from the lowest cost to the highest performance in the industry. Now you can choose a microcontroller that is "just right for your application." We have designed all the latest products to fit in National's standard cell program so they can be customized for a specific application.

The COPS™ 4-bit family of microCMOS and NMOS parts is renowned for its cost effectiveness, memory efficiency, flexibility, high reliability and years of high volume production. This family is now complemented with an 8-bit COP800 microCMOS family and a 16-bit HPC microCMOS family. These new families are designed with the Core/Modularity concept to make it easy to add additional family members. They offer a wide selection of on-board memory and peripherals.

## Support from Development to Production

We provide total support for our microcontrollers that includes evaluation boards, emulators, software packages, prototyping parts, training schools and more.

The MOLE™ (Microcomputer On Line Emulator) is a low cost Development System and Emulator common to all our microcontrollers. Our software offering includes assemblers, linkers, compilers, floating point package, etc. Your prototyping and early production needs can be easily met by our devices. Finally, we have established a special production flow to expeditiously transfer your program into Custom Masked ROM production parts.

# The COPS Solution

The COPS family of microcontrollers provides a flexible, cost-effective system solution in applications requiring timing, counting or other control functions. COPS can be used to replace discrete logic in high-volume consumer products and low-volume industrial products allowing you to add features, miniaturize and reduce component count.

- 0.5k ROM and 32 × 4 RAM to 4k ROM and 192 × 8 RAM
- ROM-efficient instruction set
- 1 μs instruction cycle time plus HALT
- Common pin-out
- Wide temperature ranges:
  − 55°C to + 125°C
- MICROWIRE™ serial communication
- Low-cost MOLE development system

National's microCMOS controllers offer a definite edge in performance. These advanced microcontrollers combine NMOS speed and bipolar ruggedness with the inherent benefits of CMOS. All the benefits of microCMOS are found in the high performance microcontroller family that includes both 4-bit and 8-bit devices.

As system designs become more complex, and as low power becomes more important in meeting design objectives, greater performance is required from microcontrollers. The COPS family provides the most cost effective system solution.

## COPS Family of Microcontrollers

| | | | | Description | | Features | | | | | | | | | Development Tools | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Memory | | I/O | | | | | | | | | | |
| Commercial Temp Version 0°C to + 70°C | Industrial Temp Version − 40°C to + 85°C | Military Temp Version − 55°C to + 125°C | Technology | ROM (Bytes) | RAM (Digits) | I/O Pins | Serial I/O | Interrupt | Stack | Time Base Count | Micro Bus | Typ. 5V Operat. Power | Max Standby at 3.3V | Size (Pins) | ROMless Device | Piggyback |
| COP413L | COP313L | | NMOS Low Power | 0.5k | 32 | 16 | Yes | No | 2 Level | No | No | 15 mW | 7.5 mW | 20 | COP401L-X13/R13 | |
| COP414L | COP314L | | NMOS Low Power | 0.5k | 32 | 16 | Yes | No | 2 Level | No | No | 15 mW | 7.5mW | 20 | COP401LN | |
| COP410L | COP310L | | NMOS Low Power | 0.5k | 32 | 19 | Yes | No | 2 Level | No | No | 15 mW | 7.5 mW | 20 | COP401LN | |
| COP411L | COP311L | | NMOS Low Power | 0.5k | 32 | 16 | Yes | No | 2 Level | No | No | 15 mW | 7.5 mW | 20 | COP401LN | |
| COP413C | COP313C | | CMOS Low Power | 0.5k | 32 | 16 | Yes | No | 2 Level | No | No | 1 mW | 0.1 mW | 20 | COP404CN | COP444CP |
| COP413CH | COP313CH | | CMOS Hi Speed | 0.5k | 32 | 16 | Yes | No | 2 Level | No | No | 1 mW | 0.1 mW | 20 | COP404CN | COP444CP |
| COP410C | COP310C | COP210C | CMOS Hi Speed | 0.5k | 32 | 19 | Yes | No | 2 Level | No | No | 1 mW | 0.1 mW | 24 | COP404CN | COP444CP |
| COP411C | COP311C | COP211C | CMOS Hi Speed | 0.5k | 32 | 16 | Yes | No | 2 Level | No | No | 1 mW | 0.1 mW | 20 | COP404CN | COP444CP |
| COP420 | COP320 | | NMOS Hi Speed | 1.0k | 64 | 23 | Yes | 1 Source | 3 Level | Yes | Yes | 100 mW | N/A | 28 | COP402N | COP420P |
| COP421 | COP321 | | NMOS Hi Speed | 1.0k | 64 | 19 | Yes | No | 3 Level | Yes | No | 100 mW | N/A | 24 | COP402N | COP420P |
| COP422 | COP322 | | NMOS Hi Speed | 1.0k | 64 | 16 | Yes | No | 3 Level | Yes | No | 100 mW | N/A | 20 | COP402N | COP420P |
| COP424C | COP324C | COP224C | CMOS Hi Speed | 1.0k | 64 | 23 | Yes | 1 Source | 3 Level | Yes | Yes | 1 mW | 0.1 mW | 28 | COP404CN | COP444CP |
| COP425C | COP325C | COP225C | CMOS Hi Speed | 1.0k | 64 | 19 | Yes | No | 3 Level | Yes | No | 1 mW | 0.1 mW | 28 | COP404CN | COP444CP |
| COP426C | COP326C | COP226C | CMOS Hi Speed | 1.0k | 64 | 16 | Yes | No | 3 Level | Yes | No | 1 mW | 0.1 mW | 20 | COP404CN | COP444CP |
| COP420L | COP320L | | NMOS Low Power | 1.0k | 64 | 23 | Yes | 1 Source | 3 Level | Yes | Yes | 45 mW | 9.9 mW | 28 | COP404LSN-5 | COP444LP |
| COP421L | COP321L | | NMOS Low Power | 1.0k | 64 | 19 | Yes | No | 3 Level | Yes | No | 45 mW | 9.9 mW | 24 | COP404LSN-5 | COP444LP |
| COP422L | COP322L | | NMOS Low Power | 1.0k | 64 | 16 | Yes | No | 3 Level | Yes | No | 45 mW | 9.9 mW | 20 | COP404LSN-5 | COP444LP |
| COP420H | COP320H | | NMOS Low Power | 1.0k | 64 | 23 | Yes | 1 Source | 3 Level | Yes | Yes | 40 mW | 9.9 mW | 28 | COP404LSN-5 | COP444LP |
| COP421H | COP321H | | NMOS Low Power | 1.0k | 64 | 19 | Yes | No | 3 Level | Yes | No | 40 mW | 9.9 mW | 24 | COP404LSN-5 | COP444LP |
| COP422H | COP322H | | NMOS Low Power | 1.0k | 64 | 16 | Yes | No | 3 Level | Yes | No | 30 mW | 9.9 mW | 20 | COP404LSN-5 | COP444LP |
| COP440 | COP340 | | NMOS Hi Speed | 2.0k | 160 | 35 | Yes | 4 Sources | 4 Level | Yes | Yes | 205 mW | 9.9 mW | 40 | COP404N | COP440R |
| COP441 | COP341 | | NMOS Hi Speed | 2.0K | 160 | 23 | Yes | 4 Sources | 4 Level | Yes | Yes | 205 mW | 9.9 mW | 28 | COP404N | COP440R |
| COP442 | COP342 | | NMOS Hi Speed | 2.0k | 160 | 19 | Yes | 2 Sources | 4 Level | Yes | No | 205 mW | 9.9 mW | 24 | COP404N | COP440R |
| COP444C | COP344C | COP244C | CMOS Hi Speed | 2.0k | 128 | 23 | Yes | 1 Source | 3 Level | Yes | Yes | 1 mW | 0.1 mW | 28 | COP404CN | COP444CP |
| COP445C | COP345C | COP245C | CMOS Hi Speed | 2.0k | 128 | 19 | Yes | No | 3 Level | Yes | No | 1 mW | 0.1 mW | 24 | COP404CN | COP444CP |
| COP444L | COP344L | | NMOS Low Power | 2.0k | 128 | 23 | Yes | 1 Source | 3 Level | Yes | No | 65 mW | 9.9 mW | 28 | COP404LSN-5 | COP444LP |
| COP445L | COP345L | | NMOS Low Power | 2.0k | 128 | 19 | Yes | No | 3 Level | Yes | No | 65 mW | 9.9 mW | 24 | COP404LSN-5 | COP444LP |

## COPS Family Development Tools

|  |  | Description |  |  |  | Features |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Memory |  | I/O |  |  |  |  |  |  |  |  |  |
| Commercial Temp Version 0°C to + 70°C | Technology | ROM (Bytes) | RAM (Digits) | I/O Pins | Serial I/O | Interrupt | Stack | Time Base Count | Micro Bus | Typ. 5V Operat. Power | Max Standby at 3.3V | Size (Pins) | Supplementary Description |
| **ROMless** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| COP401L-X13 | NMOS Low Power | 0.5k | 32 | 16 | Yes | No | 2 Level | No | No | 100 mW | 7.5 mW | 40 | Has XTAL Oscillator Option |
| COP401L-R13 | NMOS Low Power | 0.5k | 32 | 16 | Yes | No | 2 Level | No | No | 100 mW | 7.5 mW | 40 | Has RC Oscillator Option |
| COP401LN | NMOS Low Power | 0.5k | 32 | 16 | Yes | No | 2 Level | No | No | 100 mW | 7.5 mW | 40 | ROMless Version of COP410L |
| COP402N | NMOS Hi Speed | 1.0k | 63 | 20 | Yes | 1 Source | 3 Level | Yes | No | 50 mW | N/A | 40 | Has Interrupt, No Microbus |
| COP402MN | NMOS Hi Speed | 1.0k | 63 | 16 | Yes | No | 3 Level | Yes | Yes | 125 mW | N/A | 40 | No Interrupt, Has Microbus |
| COP404LSN-5 | NMOS Low Power | 1.0k | 128 | 20 | Yes | 1 Source | 3 Level | Yes | No | 125 mW | N/A | 40 | W/Push-Pull Mem Interface |
| COP404N | NMOS Hi Speed | 2.0k | 160 | 23 | Yes | 4 Sources | 4 Level | Yes | Yes | 35 mW | 15 mW | 48 | ROMless Version of COP440 |
| COP404CN | CMOS Hi Speed | 2.0k | 128 | 23 | Yes | 1 Source | 3 Level | Yes | Yes | 1 mW | 0.1 mW | 48 | CMOS ROMless Device |
| **Piggyback** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| COP420P | NMOS Hi Speed | 1.0k | 64 | 23 | Yes | 3 Sources | 3 Level | Yes | No | 50 mW | N/A | 28 | Includes CPU, RAM, I/O |
| COP444LP | NMOS Low Power | 2.0k | 128 | 23 | Yes | 3 Sources | 3 Level | Yes | No | 125 mW | N/A | 28 | and EPROM Socket |
| COP444CP | CMOS Hi Speed | 2.0k | 128 | 23 | Yes | 1 Source | 1 Level | Yes | Yes | 1 mW | 1 mW | 28 | Will Accept Standard EPROM |

# COP800C

The COP800 family is an 8-bit microcontroller that combines the powerful COPS instruction set philosophy with a memory mapped core architecture to offer the lowest cost microCMOS 8-bit microcontroller available today.

These chips are complete microcomputers on a single chip. All system timing, internal logic, ROM, RAM, and I/O are provided on the chip to produce a cost effective system solution.

The microCMOS process results in very low current drain and enables the user to select the optimum speed/power product for his system. These devices are available in various pin configurations.

## Features

- Fully static microCMOS
- 2.5V to 6.0V voltage
- 1 μs instruction cycle time
- Low current drain
- Ultra low current static halt mode
- Single supply operation
- MICROWIRE/PLUS™ serial I/O
- 20 through 44 pin packages
- Software selectable I/O options
- Fully supported by National's MOLE Development System
- E²PROM program space
- E²PROM data space
- Software selectable I/O
- 32k external program capability

## COP800 Roadmap (Basic Feature Group)

| | | | | | | | | | | | Features | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Part # | Masked ROM | RAM | EEPROM (ROM) | EEPROM (RAM) | Supply Voltage | Interrupt | Timer | I/O | Pins | Inst. Set | μW + * | WD* | MIWU* | UART | A/D Conv. | Comp | Idle | Halt | Emulator |
| COP820C | 1k | 64 × 8 | | | 2.5-6.0 | 3 | 1 | 24 | 28 | A | X | | | | | | | X | COP8720C |
| COP821C | 1k | 64 × 8 | | | 2.5-6.0 | 3 | 1 | 20 | 24 | A | X | | | | | | | X | COP8721C |
| COP822C | 1k | 64 × 8 | | | 2.5-6.0 | 3 | 1 | 16 | 20 | A | X | | | | | | | X | COP8722C |
| COP8620C | 1k | 64 × 8 | | 64 × 8 | 2.7-6.0 | 3 | 1 | 24 | 28 | A | X | | | | | | | X | COP8720C |
| COP8621C | 1k | 64 × 8 | | 64 × 8 | 2.7-6.0 | 3 | 1 | 20 | 24 | A | X | | | | | | | X | COP8721C |
| COP8622C | 1k | 64 × 8 | | 64 × 8 | 2.7-6.0 | 3 | 1 | 16 | 20 | A | X | | | | | | | X | COP8722C |
| COP8720C | | 64 × 8 | 1k | 64 × 8 | 2.7-6.0 | 3 | 1 | 24 | 28 | A | X | | | | | | | X | N/A |
| COP8721C | | 64 × 8 | 1k | 64 × 8 | 2.7-6.0 | 3 | 1 | 20 | 24 | A | X | | | | | | | X | N/A |
| COP8722C | | 64 × 8 | 1k | 64 × 8 | 2.7-6.0 | 3 | 1 | 16 | 20 | A | X | | | | | | | X | N/A |
| COP840C | 2k | 128 × 8 | | | 2.5-6.0 | 3 | 1 | 24 | 28 | A | X | | | | | | | X | COP8740C |
| COP841C | 2k | 128 × 8 | | | 2.5-6.0 | 3 | 1 | 20 | 24 | A | X | | | | | | | X | COP8741C |
| COP842C | 2k | 128 × 8 | | | 2.5-6.0 | 3 | 1 | 16 | 20 | A | X | | | | | | | X | COP8742C |
| COP8640C | 2k | 128 × 8 | | 64 × 8 | 2.7-6.0 | 3 | 1 | 24 | 28 | A | X | | | | | | | X | COP8740C |
| COP8641C | 2k | 128 × 8 | | 64 × 8 | 2.7-6.0 | 3 | 1 | 20 | 24 | A | X | | | | | | | X | COP8741C |
| COP8642C | 2k | 128 × 8 | | 64 × 8 | 2.7-6.0 | 3 | 1 | 16 | 24 | A | X | | | | | | | X | COP8742C |
| COP8740C | | 128 × 8 | 2k | 64 × 8 | 2.7-6.0 | 3 | 1 | 24 | 28 | A | X | | | | | | | X | N/A |
| COP8741C | | 128 × 8 | 2k | 64 × 8 | 2.7-6.0 | 3 | 1 | 20 | 24 | A | X | | | | | | | X | N/A |
| COP8742C | | 128 × 8 | 2k | 64 × 8 | 2.7-6.0 | 3 | 1 | 16 | 20 | A | X | | | | | | | X | N/A |

*μW + —MICROWIRE/PLUS
WD—Watch Dog Timer
MIWU—Multi-Input Wake-up

## COP800 Roadmap (High Feature Group)

| | Masked | | EEPROM | EEPROM | Supply | | | | | Inst. | Features | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Part# | ROM | RAM | (ROM) | (RAM) | Voltage | Interrupt | Timer | I/O | Pins | Set | $\mu$W + * | WD* | MIWU* | UART | A/D | Idle | Halt | Emulator |
| COP844CF | 2k | 128 × 8 | | | 2.5-6.0 | 6 | 2 | 24 | 28 | B | X | X | X | | X | X | X | COP8744C |
| COP848CF | 2k | 128 × 8 | | | 2.5-6.0 | 10 | 2 | 36 | 40 | B | X | X | X | | X | X | X | COP8784C |
| COP8644CF | 2k | 128 × 8 | | 64 × 8 | 2.7-6.0 | 6 | 2 | 24 | 28 | B | X | X | X | | X | X | X | COP8744C |
| COP8648CF | 2k | 128 × 8 | | 64 × 8 | 2.7-6.0 | 10 | 2 | 36 | 40 | B | X | X | X | | X | X | X | COP8784C |
| COP884CF | 4k | 128 × 8 | | | 2.5-6.0 | 6 | 2 | 24 | 28 | B | X | X | X | | X | X | X | COP8784C |
| COP888CF | 4k | 128 × 8 | | | 2.5-6.0 | 10 | 2 | 36 | 40 | B | X | X | X | | X | X | X | COP8788C |
| COP8684CF | 4k | 128 × 8 | | 128 × 8 | 2.7-6.0 | 6 | 2 | 24 | 28 | B | X | X | X | | X | X | X | COP8784C |
| COP8688CF | 4k | 128 × 8 | | 128 × 8 | 2.7-6.0 | 10 | 2 | 36 | 40 | B | X | x | X | | X | X | X | COP8788C |
| COP884CG | 4k | 192 × 8 | | | 2.5-6.0 | 8 | 2 | 24 | 28 | B | X | X | X | X | | X | X | COP8784C |
| COP888CG | 4k | 192 × 8 | | | 2.5-6.0 | 12 | 2 | 36 | 40 | B | X | X | X | X | | X | X | COP8788C |
| COP8684CG | 4k | 192 × 8 | | 128 × 8 | 2.7-6.0 | 8 | 2 | 24 | 28 | B | X | X | X | X | | X | X | COP8784C |
| COP8688CG | 4k | 192 × 8 | | 128 × 8 | 2.7-6.0 | 12 | 2 | 36 | 40 | B | X | X | X | X | | X | X | COP8788C |
| COP884CK | 4k | 192 × 8 | | | 2.5-6.0 | 9 | 2 | 24 | 28 | B | X | X | X | X | X | X | X | COP8784C |
| COP888CK | 4k | 192 × 8 | | | 2.5-6.0 | 13 | 2 | 36 | 40 | B | X | X | X | X | X | X | X | COP8788C |
| COP8684CK | 4k | 192 × 8 | | 128 × 8 | 2.7-6.0 | 9 | 2 | 24 | 28 | B | X | X | X | X | X | X | X | COP8784C |
| COP8688CK | 4k | 192 × 8 | | 128 × 8 | 2.7-6.0 | 13 | 2 | 36 | 40 | B | X | X | X | X | X | X | X | COP8788C |
| COP8784CK | | 192 × 8 | 4k | 128 × 8 | 2.7-6.0 | 9 | 2 | 24 | 28 | B | X | X | X | X | X | X | X | Emulator |
| COP8788CK | | 192 × 8 | 4k | 128 × 8 | 2.7-6.0 | 13 | 2 | 36 | 40 | B | X | X | X | X | X | X | X | Emulator |

*$\mu$W + —MICROWIRE/PLUS
WD—Watch Dog Timer
MIWU—Multi-Input Wake-up

# HPC: The World's First Family of 16-Bit CMOS Microcontrollers

National's new high-performance microcontroller family brings an innovative solution to the problem of making a single microcontroller satisfy the varied demands of a broad range of markets.

The internal architecture of the HPC is modular; that is, all members of the family have the same high-performance processor "core." Added to this is a different mix of memory, on-board peripherals and I/O to match specific applications.

This "perfect fit" of controller to application simplifies designs, streamlines programming and lowers systems costs.

And because the controllers are members of the same family, the user learns only one architecture, one programming language and maintains only one development system to produce products in a wide spectrum of applications.

With a 16-bit architecture implemented in microCMOS, capable of operating at speeds beyond 17 MHz, the HPC tackles designs previously considered out of the range of any microcontroller. Designed for high-throughput computation, its powerful instruction set includes a 16 × 16-bit multiply and a 32 × 16-bit divide, single-byte jumps and calls, nine addressing modes, and versatile bit-manipulation instructions.

Backing up this number-crunching power is an internal 16-bit bus to which a large set of on-board peripherals can be attached. These are UARTs, protocol controllers, timers, A/D converters, ROM, RAM, EPROM...to name a few.

This integration means that systems using the HPC will require fewer components, will operate at higher speeds, will be more reliable and will be easier to test. And because the HPC is a microCMOS device, it is fast, it uses very little power, and it operates over a wide range of supply voltages and temperatures.

| Part Numbers | | | Features | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Commercial Temperature Version 0°C to + 70°C | Industrial Temperature Version − 40°C to + 85°C | Military Temperature Version − 55°C to + 125°C | ROM | RAM | Timers | UART | I/O | Pins | Other |
| HPC46030 | HPC36030 | HPC16030 | ROMless | 256 | 8 | Yes | 52 | 68 | Standard Part |
| HPC46040 | HPC36040 | HPC16040 | 4k | 256 | 8 | Yes | 52 | 68 | Standard Part |
| HPC46073 | HPC36073 | HPC16073 | ROMless | 256 | 8 | Yes | 52 | 68 | 4-Input Capture Register |
| HPC46083 | HPC36083 | HPC16083 | 8k | 256 | 8 | Yes | 52 | 68 | 4-Input Capture Register |
| HPC46400 | HPC36400 | HPC16400 | – | 256 | 4 | Yes | 56 | 68 | 2-Channel HDLC + 4 Channel DMA |
| HPC46730 | HPC36730 | HPC16730 | ROMless | 256 | 4 | No | 55 | 68 | Gate Array with 1200 Equivalent Gates |
| HPC46740 | HPC36740 | HPC16740 | 4k | 256 | 4 | No | 55 | 68 | Gate Array with 1200 Equivalent Gates |
| HPC46900 | HPC36900 | HPC16900 | – | – | – | – | 56 | 68 | Port Expansion and Recreation Logic |

# MICROWIRE (Serial I/O) Peripherals

MICROWIRE is a serial communication scheme that allows microcontrollers to effectively communicate to peripherals and other microcontrollers (MICROWIRE/PLUS). *MICROWIRE makes efficient use of every I/O line.* MICROWIRE communication permits serial data exchange with only three wires. This reduces I/O lines, enabling the use of a more cost-effective package (i.e., fewer number of pins) or the addition of more features and capability to the final product.

| Device Number | Description | Temperature Range | Packaging Information |
|---|---|---|---|
| ADC0831 | 8-bit A/D Converter (CMOS) | C, I, M | J08, N08 |
| ADC0832 | 8-bit A/D Converter (CMOS) | C, I, M | J08, N08 |
| ADC0833 | 8-bit A/D Converter (CMOS) | C, I, M | J14, N14 |
| ADC0834 | 8-bit A/D Converter (CMOS) | C, I, M | J14, N14 |
| ADC0838 | 8-bit A/D Converter (CMOS) | C, I, M | J20, N20 |
| COP470 | Vacuum Fluorescent Display Driver | C | N20 |
| MM58241 | Vacuum Fluorescent Display Driver | C | N40 |
| MM58248 | Vacuum Fluorescent Display Driver | C | N40 |
| MM58341 | Vacuum Fluorescent Display Driver | C | N40 |
| MM58348 | Vacuum Fluorescent Display Driver | C | N40 |
| COP472-3 | Liquid Crystal Display Driver (CMOS) | C | N20 |
| MM5452 | Liquid Crystal Display Driver (CMOS) | C | N40 |
| MM5453 | Liquid Crystal Display Driver (CMOS) | C | N40 |
| MM5483 | Liquid Crystal Display Driver (CMOS) | C | N40 |
| MM58201 | Liquid Crystal Display Driver (CMOS) | C | N40 |
| MM5450 | LED Driver (NMOS) | C | N40 |
| MM5451 | LED Driver (NMOS) | C | N40 |
| MM5480 | LED Driver (NMOS) | C | N28 |
| MM5481 | LED Driver (NMOS) | C | N20 |
| MM5484 | LED Driver (NMOS) | C | N22 |
| MM5486 | LED Driver (NMOS) | C | N40 |
| COP498 | CMOS Memory and Timer | C | N14 |
| COP499 | CMOS Memory | C | N08 |
| NMC9306 | E$^2$ Memory | C | N08 |
| NMC9346 | E$^2$ Memory | C | N08 |
| DS8906 | Digital Synthesizer (AM/FM) | C | J20, N20 |
| DS8907 | Digital Synthesizer (AM/FM) | C | J20, N20 |
| DS8908 | Digital Synthesizer (AM/FM) | C | J20, N20 |
| COP452 | Frequency Generator and Counter (NMOS) | C | N14 |
| LM2893 | Bi-Line | C | N18 |
| LMC1992 | Tone Controller | C | N28 |
| LMC835 | Equalizer | C | N28 |
| LMC843 | Equalizer | C | N28 |
| TP3400 DASL | Subscriber Loop | C | N20 |
| TP3410 EL | "4" Subscriber Interface | C | TBD |
| TP3420 SDD | CCITT Interface | C | N20 |

# Microcontroller Development Systems

The MOLE (Microcontroller On Line Emulator) system was designed to support the development of all NSC microcontroller products. These include the COPS family, TMP, and the HPC family of products. The MOLE provides effective support for the development of both software and hardware in the user's application.

The purpose of MOLE is to provide the user with the tools to write and assemble code for the target microcontroller and assist in the debugging of both the hardware and software.

A MOLE system consists of three components: a MOLE Brain Board, a MOLE Personality Board, and software for the user's host computer. This partitioning provides the microcontroller design engineer with a new concept in flexibility. As an example of the flexibility consider the latitude the user has in the choice of a host CPU. The host may be IBM®-PC, Intel's MDS800, or Intellec® Series II, or Kaypro, or one of a number of inexpensive personal computers. The software provided by National Semiconductor will run under control of the host computer CP/M™ or MS-DOS™ operating system.

Further flexibility is provided by the Personality board. This component tailors the system to emulate a single microcontroller family or device. For instance, one Personality Board supports the COPS CMOS and NMOS family. This Personality Board provides support for 42 microcontroller device types.

Additionally, Personality Boards are available for the HPC family of products and the NS405 Terminal Management Processor (TMP).

The MOLE components have been designed to provide maximum utility. The host CPU contributes cost effective bulk storage and high speed processing. Disk editing and assembly operations are controlled by the host CPU. The results are down loaded to the Brain Board over the RS-232 link. The Brain Board/Personality Board combination provides FULL emulation capability.

The resident firmware allows the user to down load from the host computer, display and alter code in both hex and mnemonic format, initiate Breakpoints, Traces, and timing on addresses and external events, examine and modify the internal resources of the microcontroller being emulated. Hardware and Firmware are provided for programming EPROMs and EEPROMs.

Once debugged, the code is transmitted to National Semiconductor for use in creating the tooling necessary for manufacturing the masked microcontroller part.

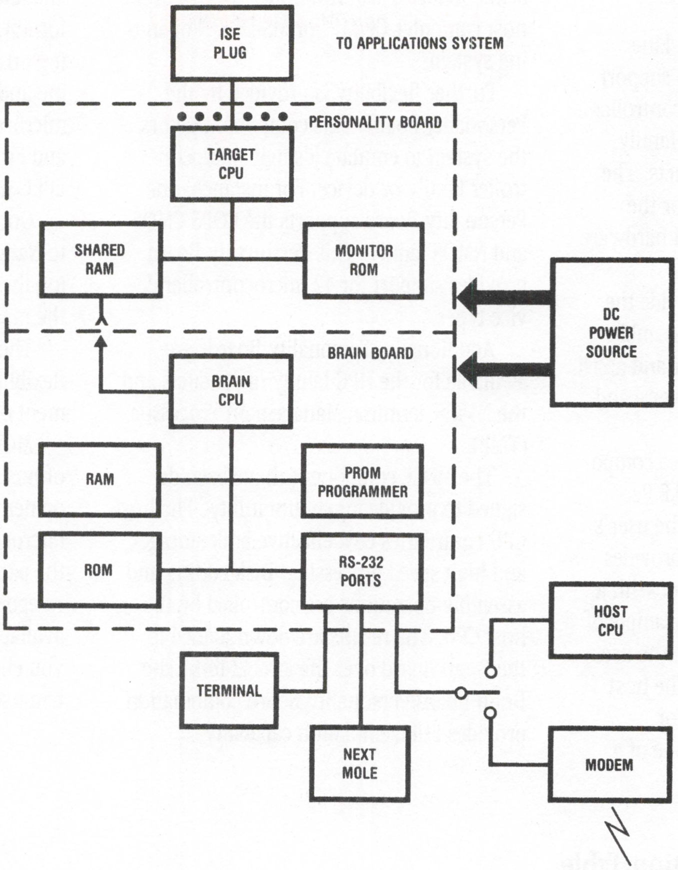
The MOLE concept provides maximum flexibility and maximum utility for development of a microcontroller based system.

MOLE systems are available for a variety of host systems. To order a complete development package, select the section for the microcontroller to be developed and order the parts listed. Order one item from each category (Items A–E). MOLE software is available for several systems; be sure that you choose the correct one for the host system used.

## Development Tools Selection Table

| Item | Description | HPC | COP800 | COP400 | TMP |
|---|---|---|---|---|---|
| A | Brain Board | MOLE-BRAIN | MOLE-BRAIN | MOLE-BRAIN | MOLE-BRAIN |
| B | Personality Board | MOLE-HPC-PB1 | MOLE-COP8-PB1 | MOLE-COPS-PB1 | MOLE-TMP-PB1 |
| C | Assembler Software for IBM (5.25″ DD Disk) | MOLE-HPC-IBM | MOLE-COP8-IBM | MOLE-COPS-IBM | MOLE-TMP-IBM |
| | Assembler Software for CP/M Systems (8″ SD Disk) | MOLE-HPC-CPM | MOLE-COP8-CPM | MOLE-COPS-CPM | MOLE-TMP-CPM |
| | Assembler Software for Intel Single Density Systems (8″ SD Disk) | MOLE-HPC-INT-S | MOLE-COP8-INT-S | MOLE-COPS-INT-S | MOLE-TMP-INT-S |
| | Assembler Software for Intel Double Density Systems (8″ DD Disk) | MOLE-HPC-INT-D | MOLE-COP8-INT-D | MOLE-COPS-INT-D | MOLE-TMP-INT-D |
| | Assembler Software for KAYPRO2 (5.25″ DD Disk) | MOLE-HPC-KAY | MOLE-COP8-KAY | MOLE-COPS-KAY | MOLE-TMP-KAY |
| | C Compiler for IBM (5.25″ DD Disk) Includes Assembler Software for IBM | MOLE-HPC-IBM-C | MOLE-COP8-IBM-C<br>Available 1988 | | |
| D | Programmers Manual | 420410704-001 | 420410703-001 | 424410284-001 | 420040401-001 |
| E | Hardware Manual | 420410705-001 | | | |

## MOLE System Block Diagram


ISE PLUG
TO APPLICATIONS SYSTEM
PERSONALITY BOARD
TARGET CPU
SHARED RAM
MONITOR ROM
DC POWER SOURCE
BRAIN BOARD
BRAIN CPU
RAM
PROM PROGRAMMER
ROM
RS-232 PORTS
HOST CPU
TERMINAL
NEXT MOLE
MODEM

## Dial-A-Helper

Dial-A-Helper is a service provided by the MOLE (Microcontroller On Line Emulator) applications group. It consists of both an electronic bulletin board information system and a method by which applications can take control of a MOLE Development System at a remote site via modem in order to resolve any problems.

### Information System

The Dial-A-Helper system provides access to an automated information storage and retrieval system that may be accessed over standard dial-up telephone lines 24 hours a day. The system capabilities include a MESSAGE SECTION (electronic mail) for communications to and from the Microcontroller Applications Group and a FILE SECTION mode that can be used to search out and retrieve application data about NSC Microcontrollers. The user needs as a minimum, a Dumb terminal, 300 or 1200 baud Modem, and a telephone.

If the user has a PC with a communications package then files from the FILE SECTION can be down loaded to disk for later use.

### Factory Applications Support

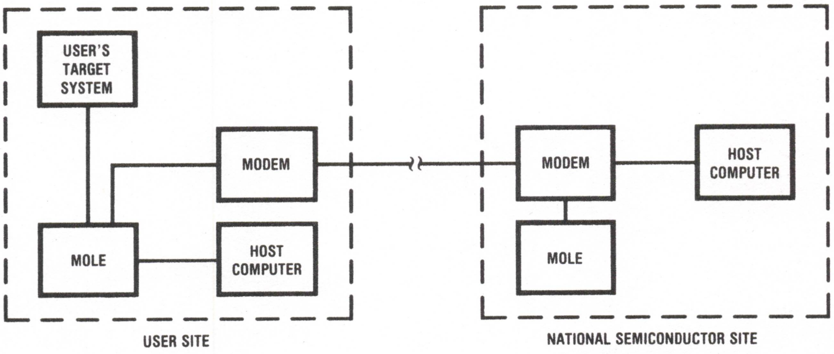
Dial-A-Helper also provides immediate factory applications support. If a user is having difficulty in getting a MOLE to operate in a particular mode or something peculiar is occurring, he can contact us via his system and modem. He can leave messages on our electronic bulletin board, which we will respond to, or he can arrange for us to actually take control of his system via modem for debugging purposes.

The applications group can then cause his system to execute various commands and try to resolve the customer's problem by actually getting the customer's system to respond. Both parties see exactly what is occurring, as it is happening.

This allows us to respond in minutes when applications help is needed.

**Data Line:** (408) 739-1162
**Voice Line:** (408) 721-5582

**Dial-A-Helper**



## 8050 Family

The NS8048/49/50 family of single chip microcontrollers are available with 1k, 2k and 4k of masked ROM. The 8050U family combines the standard features of the 8050 microcontroller with National's 3-wire serial data communication called MICROWIRE. This feature allows communication between two 8050Us or one 8050U and other MICROWIRE peripherals (such as A/D converters, LCD or VF display drive, etc.). To assist in development as well as some production requirements, National offers a piggyback device to allow the use of EPROMs instead of masking the device. The pig, as it is called, NS87P50U is an exact emulation of the 8050 family of devices.

| Device Type | Program Storage | Program Size | Internal RAM | Temperature Ranges Available (°C) | Package |
|---|---|---|---|---|---|
| INS 8035 | ROMless | 1k | 64 | 0 to +70, −40 to +85 | 40N |
| INS 8039 | ROMless | 2k | 128 | 0 to +70, −40 to +85 | 40N |
| NS8040U | ROMless | 4k | 256 | 0 to +70, −40 to +85 | 40N |
| INS 8048 | Mask ROM | 1k | 64 | 0 to +70, −40 to +85 | 40N |
| INS 8049 | Mask ROM | 2k | 128 | 0 to +70, −40 to +85 | 40N |
| NS8050U | Mask ROM | 4k | 256 | 0 to +70, −40 to +85 | 40N |
| NS87P50U | ROMless (Piggyback) | 4k | 256 | 0 to +70 | 40D |

All devices are available in low power, 6 MHz or 11 MHz and commercial or industrial temperature ranges.

## I/O Expander

| Device | Description | Temperature Range (°C) | Package |
|---|---|---|---|
| INS 8243 | Input/Output Expander | 0 to +70 | N24 |

# Series Display Management Processor (TMP)

The NS405 and NS455 are a family of LSI devices providing CRT display functions on a single chip. Conventional terminals consist of many LSI devices including:

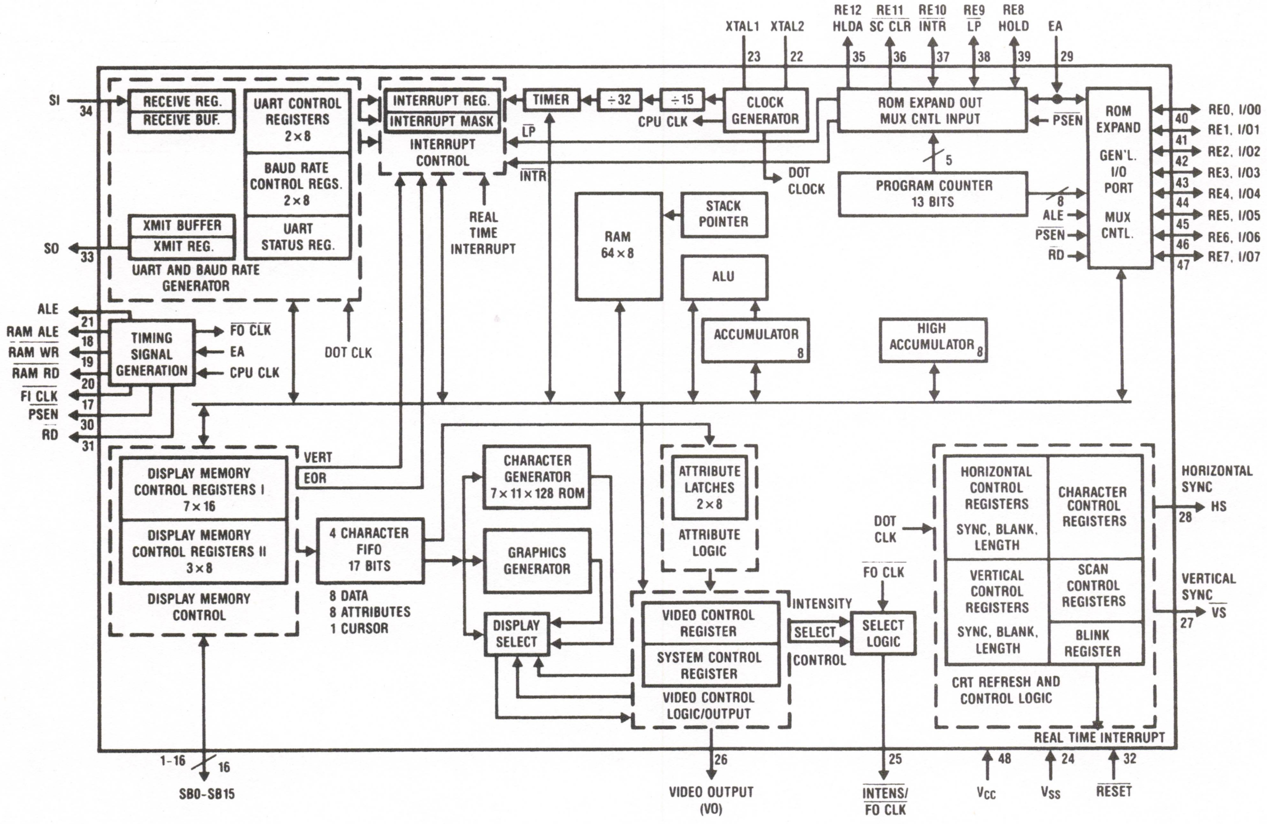
- Microprocessor
- ROM/PROM/EPROM
- CRT Controller
- DMA Controller
- Character Generator
- Video Memory Controller
- UART
- Baud Rate Generator
- Interrupt Controller
- Parallel I/O
- Timers

The display management processor series of chips contains all the functions listed above, allowing small, low cost and highly reliable display electronics. Displays compatible with TMP designs include terminals, point of sale displays, lottery terminals, machine control displays, plasma displays and many others.

## Features

- Enhanced 8048 instruction set and architecture
- Up to 8k × 8 ROM external with ROM expand bus
- On-board RAM 64 × 8
- Programmable display format
- On-board video memory management unit
- 16-bit bidirectional display memory bus (direct video and attribute RAM interface)
- Built-in timer
- Real-time clock (may be programmed for 1 Hz)
- Video control signals
- Eight independent attributes
- Pixel and block graphics display modes
- Programmable cursor characteristics
- Programmable CRT refresh rate
- Light pen feature
- UART, programmable baud rate up to 19.2k baud
- Character generator (128 characters 7 × 11 max)
- Single 5V supply @ 110 mA (typ)
- Up to 18 MHz video dot rate (12 MHz CPU clock)
- 48-pin package
- 8-bit parallel I/O port (multiplexed with external ROM)
- Extensive I/O expansion capabilities
- Up to 64k by 8 or 16 video RAM

**NS405**


XTAL1 XTAL2
RE12 HLDA
RE11 SC CLR
RE10 INTR
RE9 LP
RE8 HOLD
EA
23 22 35 36 37 38 39 29
SI 34
RECEIVE REG.
RECEIVE BUF.
UART CONTROL REGISTERS 2×8
BAUD RATE CONTROL REGS. 2×8
XMIT BUFFER
XMIT REG.
UART STATUS REG.
UART AND BAUD RATE GENERATOR
SO 33
INTERRUPT REG.
INTERRUPT MASK
INTERRUPT CONTROL
LP
INTR
TIMER
÷32
÷15
CPU CLK
CLOCK GENERATOR
DOT CLOCK
ROM EXPAND OUT MUX CNTL INPUT
PSEN
5
PROGRAM COUNTER 13 BITS
8
ALE
PSEN
RD
ROM EXPAND
GEN'L. I/O PORT
MUX CNTL.
40 RE0, I/O0
41 RE1, I/O1
42 RE2, I/O2
43 RE3, I/O3
44 RE4, I/O4
45 RE5, I/O5
46 RE6, I/O6
47 RE7, I/O7
REAL TIME INTERRUPT
RAM 64×8
STACK POINTER
ALU
ACCUMULATOR 8
HIGH ACCUMULATOR 8
ALE 21
RAM ALE 18
RAM WR 19
RAM RD 20
FI CLK 17
PSEN 30
RD 31
TIMING SIGNAL GENERATION
FO CLK
EA
CPU CLK
DOT CLK
DISPLAY MEMORY CONTROL REGISTERS I 7×16
DISPLAY MEMORY CONTROL REGISTERS II 3×8
DISPLAY MEMORY CONTROL
VERT
EOR
4 CHARACTER FIFO 17 BITS
8 DATA
8 ATTRIBUTES
1 CURSOR
CHARACTER GENERATOR 7×11×128 ROM
GRAPHICS GENERATOR
DISPLAY SELECT
ATTRIBUTE LATCHES 2×8
ATTRIBUTE LOGIC
VIDEO CONTROL REGISTER
SYSTEM CONTROL REGISTER
VIDEO CONTROL LOGIC/OUTPUT
INTENSITY
SELECT
CONTROL
DOT CLK
FO CLK
SELECT LOGIC
HORIZONTAL CONTROL REGISTERS
SYNC, BLANK, LENGTH
CHARACTER CONTROL REGISTERS
VERTICAL CONTROL REGISTERS
SYNC, BLANK, LENGTH
SCAN CONTROL REGISTERS
BLINK REGISTER
CRT REFRESH AND CONTROL LOGIC
HORIZONTAL SYNC
28 HS
VERTICAL SYNC
27 VS
REAL TIME INTERRUPT
1-16 16
SB0-SB15
26
VIDEO OUTPUT (VO)
25
INTENS/FO CLK
48 Vcc
24 Vss
32 RESET

## TMP Products

| Device Type | Program Storage | Character Font* | Video Rate | Maximum No. of Columns |
|---|---|---|---|---|
| NS405-A12N | ROMless | A | 12 MHz | 80 |
| NS405-B18N | ROMless | B | 18 MHz | 80 |
| NS405-C12N | ROMless | C | 12 MHz | 80 |
| NS405-B12N | ROMless | B | 12 MHz | 80 |
| NS455-A12N | Masked ROM | A | 12 MHz | 80 |

*A type font is a standard 5 × 7 font.
B type font is a standard 7 × 9 font.
C type font is a standard 6 × 8 type VT 100 font.

| Development Support | | | Order Part Numbers |
|---|---|---|---|
| MOLE—Brain Board | A single board general purpose development system. | | MOLE-BRAIN |
| TMP—Personality Board | | | MOLE-TMP-PB1 |
| TMP Demo Board | A fully functional board implementing TMP for direct connect to a CRT. | 12 MHz | TMP-DEMO-12 |
| | | 18 MHz | TMP-DEMO-18 |
| Applications Manual | A comprehensive technical manual about TMP. | | 420040401-001 |

# Microprocessors

For additional Microprocessor products, see pages 321 and 451.

# Microprocessors

In 1983, National Semiconductor released the first full 32-bit microprocessor, years ahead of the closest competition.

Now, Series 32000®, the only complete family of 32-bit microprocessors, offers clear advantages to the designer: Better price/performance ratios, architecture with a clear migration path and a complete hardware/software solution.

Designed from the top down, it began as a true 32-bit solution, rather than having evolved from more primitive 8-bit and 16-bit architectures. The CPUs, for example, all have a 32-bit arithmetic logic unit (ALU), 32-bit dedicated and general-purpose registers and 32-bit internal data paths.

And the CPU coprocessors are exact architectural complements of each other, operating efficiently, effectively and more compactly.

This is true of the complete Series 32000 computing cluster: Memory Management, Floating Point, Interrupt Control, Timing Control and DMA Control.

Series 32000 includes development systems, evaluation boards, software programs and engineering support. Also peripherals: DRAM controllers, advanced graphics support, LAN interface chips, data communications, disk control and interface.

The software you write for one Series 32000 microprocessor is compatible with every other microprocessor in the family. And because the migration path has been so well planned, you have complete upward and downward software compatibility. The architectural continuity National provides allows for a totally transparent user interface.

Best of all, Series 32000 is supported by the manufacturing strength and capacity to deliver high-quality, high-reliability devices at a reasonable cost. As a leader in 32-bit technology, stable and committed to the 32-bit market, National Semiconductor assures you availability of parts, now and in the future.

Currently, Series 32000 is the only 32-bit family that offers complete programs for military and other high-reliability applications, including: MIL-STD-883, JAN 38510, radiation-hardened versions (1Mrad) and Ada® development support.

The net of this is that designers get flexibility and completeness, while drastically cutting development times. So you can concentrate on designing systems, rather than trying to overcome limited hardware solutions. And your software investment is protected.

No one has more experience in the 32-bit market. And no one does more—with an integrated family of devices, development tools, and software—to put that experience to work for you.

## Series 32000 Components

| Device | Description | Bus Width | | | Process | Package Type |
|---|---|---|---|---|---|---|
| | | | External | | | |
| | | Internal | Address | Data | | |
| **Central Processing Units** | | | | | | |
| NS32032 | Central Processing Unit — CPU with 32-bit architecture and 32-bit data bus supporting a large address space. The 16 Mbyte uniform address space, powerful two-address instruction set and symmetrical addressing modes support both assembly and high level language code generation. NS32032 is upward and downward compatible to 8, 16 and 32-bit Series 32000 microprocessors. The architecture provides full virtual memory capabilities using the NS32082 MMU. High performance floating-point instructions are provided with NS32081 FPU. | 32 | 24 | 32 | XMOS™<br>(NMOS) | 68-pin LCC<br>Leadless Chip Carrier<br>68-pin PLCC |
| NS32016 | Central Processing Unit — CPU functionally the same as NS32032 with 16-bit data bus. | 32 | 24 | 16 | XMOS<br>(NMOS) | 48-pin DIP<br>Dual-In-Line Package<br>68-pin PLCC |
| NS32016RT | NS32016 CPU specially configured for Real Time (embedded control) applications not requiring virtual memory support. | 32 | 24 | 16 | XMOS<br>(NMOS) | 48-pin DIP<br>68-pin PLCC |
| NS32008 | Central Processing Unit — CPU functionally the same as NS32032 with 8-bit data bus. | 32 | 24 | 8 | XMOS<br>(NMOS) | 48-pin DIP<br>Dual-In-Line Package<br>68-pin PLCC |
| NS32C032 | CMOS CPU Central Processing Unit — CMOS version of NS32032. Internal and external architecture the same as NS32032. Pin compatible with the NS32032 processed in XMOS. | 32 | 24 | 32 | CMOS | 68-pin LCC<br>Leadless Chip Carrier<br>68-pin PLCC |
| NS32C016 | CMOS CPU Central Processing Unit — CMOS version of NS32016. Internal and external architecture the same as NS32016. Pin compatible with NS32016 processed in XMOS. | 32 | 24 | 16 | CMOS | 48-pin DIP<br>Dual-In-Line Package<br>68-pin PLCC |
| NS32C016RT | NS32C016 CPU specially configured for Real Time (embedded control) applications not requiring virtual memory support. | 32 | 24 | 16 | CMOS | 48-pin DIP<br>68-pin PLCC |
| NS32132 | Central Processing Unit — CPU same internal and external architecture as NS32032 with addition of dual processor bus arbitration logic on-chip. | 32 | 24 | 32 | XMOS<br>(NMOS) | 68-pin LCC<br>Leadless Chip Carrier |
| NS32332 | Central Processing Unit — Second generation 32-bit CPU with enhanced internal micro-architecture. Supports 4 Gbyte uniform address space. Extensive support for cache memories and multiprocessing. Features burst mode memory access and dynamic bus configuration to 8, 16 and 32 bits. | 32 | 32 | 32 | XMOS<br>(NMOS) | 84-pin PGA<br>Pin-Grid Array |
| NS32332RT | NS32332 CPU specially configured for Real Time (embedded control) applications not requiring virtual memory support. | 32 | 32 | 32 | XMOS<br>(NMOS) | 84-pin PGA |
| **Slave Processors** | | | | | | |
| NS32081 | Floating Point Unit — FPU provides high-speed floating point instructions for single (32-bit) and double (64-bit) precision. Supports IEEE standard for binary floating point arithmetic. Compatible with NS32016, NS32C016, NS32008, NS32C032, NS32032, NS32132 and NS32332 CPUs. | 64 | — | 16 | XMOS<br>(NMOS) | 24-pin DIP<br>Dual-In-Line Package<br>44-pin PLCC |
| NS32381 | Floating Point Unit — Second generation FPU. Provides high-speed floating point instructions for single (32-bit) and double (64-bit) precision. Supports IEEE standard for binary floating point arithmetic. Compatible with NS32332. | 64 | — | 32 | CMOS | 68-pin PLCC |
| NS32C081 | CMOS Floating Point Unit — FPU provides high-speed floating point instructions for single (32-bit) and double (64-bit) precision. Supports IEEE standard for binary floating point arithmetic. Compatible with NS32016, NS32C016, NS32008, NS32C032, NS32032, NS32132 and NS32332 CPUs. | 64 | — | 16 | CMOS | 24-pin DIP<br>Dual-In-Line Package<br>44-pin PLCC |

## Series 32000 Components (Continued)

| | | Bus Width | | | | |
|---|---|---|---|---|---|---|
| | | | External | | | |
| Device | Description | Internal | Address | Data | Process | Package Type |
| **Slave Processors** | | | | | | |
| NS32382 | Memory Management Unit — Second generation MMU works in conjunction with NS32332. Full 32-bit architecture and supports 4 Gbyte address space. Supports enhanced slave protocol. | 32 | 32 | 32 | XMOS | 125-pin PGA Pin-Grid Array |
| NS32082 | Memory Management Unit — MMU provides hardware support for demand-paged virtual memory. Supports fast dynamic two-level address translation and protection on individual 512-byte pages. Manages up to 32 Mbytes of physical storage. High speed address translation performed on-chip through 32-entry associative cache. Memory protection supports access-level checking and dual address maps. | 32 | 24 | 16 | XMOS (NMOS) | 48-pin DIP Dual-In-Line Package |
| **Peripherals** | | | | | | |
| NS32301 | Timing Control Unit — Second generation TCU for Series 32000. Provides all the essential functions in the NS32201-10. Key features include support for burst mode and cache interface features of the NS32332 second generation CPU. | — | — | — | Bipolar | 28-pin DIP Dual-In-Line Package |
| NS32201 | Timing Control Unit — TCU fabricated on a Schottky bipolar process. Provides a two-phase clock, system control logic and cycle extension logic for Series 32000 CPUs. TCU provides extremely accurate bus control signals and cycle timing over the bus. | — | — | — | Bipolar | 24-pin DIP Dual-In-Line Package |
| NS32C201 | CMOS TCU Timing Control Unit — NS32C201 CMOS TCU fabricated using NSC microCMOS technology with TTL compatible inputs. Same as NS32201 functionally. For use with CMOS CPUs. | — | — | — | CMOS | 24-pin DIP Dual-In-Line Package<br>44-pin PLCC |
| NS32202 | Interrupt Control Unit — ICU minimizing the software and real-time overhead required to handle multi-level, prioritized interrupts. Single ICU manages up to 16 interrupt sources and resolves interrupt priorities. Expandable up to 256 interrupts using multiple ICUs. | 32 | — | 16 | XMOS (NMOS) | 40-pin DIP Dual-In-Line Package |
| NS32203 | Direct Memory Access Controller — DMA relieves CPU of data transfers between memory and I/O devices. Transfer rates up to 5 Mbytes per second. Performs memory to memory, I/O to I/O, or memory to I/O transfers. Interfaces with Series 32000 microprocessors. | — | — | 16 | XMOS (NMOS) | 48-pin DIP Dual-In-Line Package |

## Series 32000 Support Devices

| Device | Description | Package Type |
|---|---|---|
| **Disk Control and Interface** | | |
| NS32951/DP8451 | Disk Data Synchronizer — Frequency lock in Read Mode until 16 bits of synch field are recognized. Frequency lock in Non-Read Mode. | 20-pin Plastic DIP<br>20-pin Plastic Chip Carrier |
| NS32955/DP8455 | Disk Data Synchronizer — Phase lock in Read Mode. Frequency lock in Non-Read Mode. | 20-pin Plastic DIP<br>20-pin Plastic Chip Carrier |
| NS32961/DP8461 | Disk Data Synchronizer and MFM Separator — Frequency lock in Read Mode until 16 bits of synch field are recognized. Frequency lock in Non-Read Mode. | 24-pin Plastic DIP or<br>28-pin Plastic Chip Carrier |
| NS32962/DP8462 | Disk Data Synchronizer for 2, 7 Code — Frequency lock until 100 or 1000 synch field is detected (selectable). Frequency lock in the Non-Read Mode. | 24-pin Plastic DIP or<br>28-pin Plastic Chip Carrier |
| NS32963/DP8463 | Disk 2, 7 Code Encoder/Decoder — Provides disk system the ability to record up to 50% message data in the same media space without any increase in the flux changes per inch. | 28-pin Plastic DIP or<br>28-pin Plastic Chip Carrier |
| NS32964/DP8464B | Disk Pulse Detector — On-chip differential gain controlled amplifier. Differentiator, compare gating circuitry and output pulse generator. | 24-pin Plastic DIP or<br>28-pin Plastic Chip Carrier |
| NS32965/DP8465 | Disk Data Synchronizer and MFM separator — Phase lock in Read Mode. Frequency lock in Non-Read Mode. | 24-pin Plastic DIP or<br>28-pin Plastic Chip Carrier |

## Series 32000 Support Devices (Continued)

| Device | Description | Package Type |
|---|---|---|
| **Disk Control and Interface** | | |
| NS32966/DP8466 | Disk Data Controller — Interfaces Winchester/floppy disk drives. Transfers data rates up to 24 Mbits per second. High speed system data transfer with full on-chip DMA control. 16-bit system I/O interface. Programmable track format enables reconfiguration for different drive types in multiple drive environment. | 48-pin Plastic DIP or<br>68-pin Plastic Chip Carrier |
| **DRAM Interface** | | |
| NS32800-2/DP8400-2 | 16-bit Expandable Error Checker and Corrector — $E^2C^2$. Directly expandable in 16-bit increments to any word width. Detects and corrects single and double bit errors. Error detection 20 ns (typical). Error detection and correction 40 ns (typical). | 48-pin Plastic DIP<br>48-pin Ceramic DIP<br>68-pin Plastic Chip Carrier |
| NS32082A/DP8402A | 32-bit parallel Error Detector and Corrector-EDAC. Detects and corrects all single bit errors while flagging double bit errors. Error detection 25 ns (typical). Error detection and correction 45 ns (typical). | 52-pin Ceramic DIP<br>68-pin Plastic Chip Carrier |
| NS32809A/DP8409A | 256K DRAM Controller/Driver. Multiple refresh and access modes. Direct drive up to 2 Mbytes plus error correction check bits. | 48-pin Plastic DIP<br>48-pin Ceramic DIP<br>68-pin Plastic Chip Carrier |
| NS32812/DP84412 | Series 32000 to DP8409/19 Interface. Performs refresh/access arbitration function. | 20-pin Plastic DIP<br>20-pin Ceramic DIP |
| NS32819/DP8419 | 256K DRAM Controller/Driver. No CPU WAIT states at 10 MHz and faster. Direct drive up to 2 Mbytes plus error correction check bits. | 48-pin Plastic DIP<br>48-pin Ceramic DIP<br>68-pin Plastic Chip Carrier |
| **Timer Clock** | | |
| NS32870/DP8570 | Real Time Clock/Calendar. Two 10 MHz 16-bit programmable timers, on-chip powerfail detect circuits. Periodic/alarm/powerfail interrupts and 33 bytes of scratchpad CMOS RAM. Data Bus — Read/Write Access: 150 ns (max). | 28-pin DIP<br>28-pin Plastic Chip Carrier |
| **Data Communications and LANs** | | |
| NS32455/NS455 | Terminal Management Processor — TMP integrates CPU, program memory, scratch RAM, video control, video timing, character generator, video memory control, serial UART, and parallel I/O. Standard terminal program contained in internal ROM. | 48-pin Plastic DIP |
| NS32405/NS405 | TMP — ROMless version of NS32455/NS455. | 48-pin Plastic DIP |
| NS32490/DP8390 | Local Area Network Interface Controller — Provides all of the protocol and networking functions as specified in the IEEE 802.3 Ethernet/Cheapernet LAN Standard. Features dual DMA capability. | 48-pin Plastic DIP |
| NS32491/DP8391 | Serial Network Interface — Digital PLL design provides a fast lock high jitter tolerance interface to the 802.3 Network. | 24-pin Plastic Narrow DIP |
| NS32492/DP8392 | Coax Transceiver Interface — Integrates the transmitter, receiver, collision detector and jabber timer functions specified in the 802.3 into one 16-pin package. Unique power package designed for stringent reliability requirement. | 16-pin Plastic DIP |
| NS32440/DP8340 | IBM 3270 Biphase Serial Encoder/Transmitter — Generates the complete encoding of parallel data for serial transmission (2.3587 Mbits/sec) which conforms to the IBM 3270 Information Display Standard. | 24-pin Plastic DIP<br>24-pin Ceramic DIP<br>28-pin Plastic Chip Carrier |
| NS32441/DP8341 | IBM 3270 Biphase Serial Decoder/Receiver provides complete decoding of high speed serial data which conforms to the IBM 3270 Information Display Standard. | 24-pin Plastic DIP<br>24-pin Ceramic DIP<br>28-pin Plastic Chip Carrier |
| NS32442/DP8342 | High Speed Serial Manchester Encoder/Transmitter — Generates complete encoding of parallel data for serial transmission of 8-bit data bytes at up to 3.5 Mbits/sec using coax, twisted pair, fiber optics, etc. | 24-pin Plastic DIP<br>24-pin Ceramic DIP<br>28-pin Plastic Chip Carrier |
| NS32443/DP8343 | High Speed Serial Manchester Decoder/Receiver — Provides complete decoding of high speed serial data sent from the NS32442/DP8342. | 24-pin Plastic DIP<br>24-pin Ceramic DIP<br>28-pin Plastic Chip Carrier |

## Series 32000 Development Products

| Device | Description | User Support | RAM Memory | Mass Storage | | |
|---|---|---|---|---|---|---|
| | | | | Hard Disk | Floppy Disk | Streamer Tape |
| **Development Systems** | | | | | | |
| SYS32/20 | A complete development solution for the support of the Series 32000 microprocessor family in the Personal Computer (PC) environment. Allows mainframe-size programs to run on a PC at speeds similar to those of a VAX/780. Consists of a 32-bit Series 32000-based PC add-in board, complete binary port of AT&T System V o/s, specially developed software which integrates the System V and DPS Operating Systems, NSC's Series 32000 Language Tools (GNX), and complete manuals set including AT&T System V Manual Set. Order as NSS-SYS20-KITX. | 2 | 2 Mbyte or 4 Mbyte | Dependent Upon PC-Host Configuration | | |
| VR32 | Two-User Target/Development System (TD/S). Provides development support for Series 32000 components. (See SYS32 description). Also provides customized solutions for system implementations through the use of reconfigurable hardware and software. Fortran77 Compiler, C Compiler, and Series 32000 assembler are included with System V/Series 32000 UNIX operating system. Pascal compiler is optional. Supports demand-paged virtual memory, record and file locking, and emulation for Series 32000. (See ISE32 and ISE16 descriptions). Order as NSS-VR32-XXXX. | 2 User Expandable | 1 Mbyte 3 Card Slots Available for Expansion | 40 Mbyte | 1 Mbyte | 20 Mbyte (Optional) |

| Device | Description | Devices Supported | Modes | Emulator Memory | Program Flow Tracing | Triggering |
|---|---|---|---|---|---|---|
| **In System Emulators** | | | | | | |
| ISE32 | Powerful tool for hardware and software development of NS32032 microprocessor-based product. Used with a host, ISE32 emulates the NS32032 CPU, NS32082 MMU, and NS32201 TCU. Order as NSS-ISE32. | NS32032<br>NS32201<br>NS32082 | Stand-Aside Mode or Transparent Mode | 128 Kbyte | 1023 Non-Sequential Fetches | Pre-Post Center |
| ISE16 | Functionally same as ISE32. Supports emulation of NS32016 CPU, NS32082 MMU, and NS32201 TCU. Order as NSS-ISE16. | NS32016<br>NS32201<br>NS32082 | Stand-Aside Mode or Transparent Mode | 30 Kbyte | 255 Non-Sequential Fetches | Pre-Post Center |

| Device | Description | Devices Supported | Memory Capacity |
|---|---|---|---|
| **Development Boards** | | | |
| DB32332 | Like the DB32016 and DB32032 development/evaluation board products, DB32332 board provides a platform to assist the evaluation and development of Series 32000-based applications. Contains a monitor firmware program for direct communication with programs developed on a larger host computer system with National's C, Pascal and even FORTRAN77 software packages. DB32332 is based on the NS32332 CPU. Order as NSV-32332XXX. | NS32332 CPU<br>NS32082 MMU<br>NS32201 TCU<br>NS32081 FPU<br>NS32202 ICU | 1MB DRAM expandable to 2MB<br>2MB DRAM<br>64 Kbytes of JEDEC EPROM |
| DB32000 (NS32032 based) | Enables evaluation of the architecture, instruction set, cycle timing and bus interfaces for Series 32000. Small programs can be written, assembled, debugged and executed with TDS (Tiny Development System) software. DB32000 provides a native debug/execution environment for programs developed on a larger host computer with National's C and Pascal cross software packages. DB32000 is based on the NS32032 CPU. Order as NSV-32032XXX. | NS32032 (Can be replaced with NS32016 or NS32008 CPUs for evaluation).<br>NS32082 MMU, NS32081 FPU<br>NS32202 ICU and NS32201 TCU<br>Socket provides for CPU dual processing. Two RS232 ports.<br>Wire wrap area for user expansion. | 256 Kbytes DRAM<br>Expandable to Mbytes<br>Up to 256 Kbytes of EPROM in two banks |

## Series 32000 Development Products (Continued)

| Device | Description | Devices Supported | Memory Capacity |
|---|---|---|---|
| **Development Boards** | | | |
| DB32016 (NS32016 based) | Development Board designed to assist evaluation/development of application. Provides vehicle for evaluating performance of Series 32000 microprocessors, slave processors and support chips. Small programs can be written, assembled, debugged and executed with TDS (Tiny Development System) software. DB32016 provides a native debug/execution environment for programs developed on a larger host computer with National's C and Pascal cross software packages. DB32016 is based on the NS32016 CPU. Order as NSV-32016XXX. | NS32016 CPU (Can be replaced with NS32008 for evaluation)<br>NS32082 MMU<br>NS32081 FPU<br>NS32202 ICU and NS33201 TCU<br>MULTIBUS® interface and two RS232 ports. | 128 Kbytes RAM<br>Up to 96 Kbytes PROM |
| **OEM Board Level Products** | | | |
| ICM-332-1 System<br>ICM-332-1-10CPU CPU Board | ICM-332-1 is a complete computer system on two printed circuit boards (minimum configuration for the system — CPU and IOP boards). The CPU board contains the full Series 32000 chip set (CPU, MMU, FPU, TCU, ICU), two megabytes of 150 ns dynamic RAM and a 32-bit Memory bus. The board contains the high-performance NS32332 CPU. The CPU board operates at 10 MHz. Since the I/O Processor controls all the I/O for the system, the computing complex on the CPU board can be dedicated full time to computing. (See ICM-332-1-1IOP Description)<br>• Complete Series 32000 chip set (NS32332 CPU)<br>• NS32016 I/O processor<br>• High speed DMA mover to/from system memory<br>• Centronics-compatible printer port<br>• Four asynchronous RS323C-compatible serial ports<br>• Small Computer System Interface (SCSI) port<br>• Minibus expansion bus for interfacing special purpose modules<br>• 2 to 14 Mbytes of random access memory with byte parity<br>• GENIX V.3 (NSC's version of UNIX V.3) available as an option | NS32332-CPU<br>NS32201-TCU<br>NS32082-MMU<br>NS32081-FPU<br>NS32202-ICU | 2 Mbytes reside on CPU Board |
| I/O Processor (IOP) board for ICM-332-1 system.<br>ICM-332-1-1IOP | The IOP handles the interface with the real world. The I/O Processor board contains the serial ports, printer port, SCSI interface, Minibus and 512 Kbytes of private RAM. The NS32016 CPU on the IOP board is used to control all I/O functions for the system. Interface to the CPU board is accomplished with a high speed DMA circuit. | NS32016 CPU<br>NS32201 TCU<br>NS32202 ICU | |
| Memory Board for ICM-332-1<br>ICM-332-1-10-06 | Each memory expansion board for ICM-332 is 6 Mbytes of memory. An additional 12 megabytes of memory can be added to a system with the addition of 1 or 2 expansion boards. | | Up to 14 Mbytes with additional Memory boards |
| ICM-332-1 Operating System GENIX V.3<br>ICM-332-1UNV30BT | GENIX V.3 is National's certified port of AT&T System V Release 3.0 UNIX operating system. GENIX V.3 is an enhancement over V.2 featuring Streams, Networking support, and Remote File System. This operating system provides optimal use of Series 32000 architecture. It supports demand-paged virtual memory and offers Job Control as well as File and Record Locking. C and FORTRAN compilers and the Series 32000 assembler are available. Reconfigurable binary drivers are included for rigid disk, floppy disk, streamer tape, serial ports and the printer port. | | |
| ICM R&D kit for ICM-332-1 System<br>ICM-332-1-RD02 | The ICM-332 R&D kit provides the user with a complete computer on two boards (CPU board and IOP board is the minimum configuration). The R&D kit includes GENIX V.3 (a certified port of AT&T's System V Release 3.0 Unix OS), Monitor/bootloader EPROM, a complete set of manuals, and the necessary cabling between components. Requires the addition of controllers, disk and tape drives, power supply and terminal. Requires binary user license to be signed prior to shipment. | ICM-332-1 R&D Kit includes:<br>CPU Board (ICM-332-1-10CPU)<br>IOP Board (ICM-332-1-1IOP)<br>GENIX V.3 (ICM-332-1UNV30BT)<br>Monitor EPROM (ICM-332-1MON)<br>Manuals/Adaptors/Cables | |

## Series 32000 Development Products (Continued)

| Device | Description | Devices Supported | Memory Capacity |
|---|---|---|---|
| ICM-3216 System<br>ICM-3216 CPU Board | The ICM-3216 is a complete computer system contained on 2-3 11.02 inch by 9.18 inch printed circuit boards. This Integrated Computer Module (ICM) utilizes the power of the Series 32000 chip set. The CPU cluster, serial ports, printer port, SCSI interface and MiniBus Interface reside on the CPU unit.<br>• Uses the complete Series 32000 chip set (CPU, TCU, MMU, FPU and ICU).<br>• 1 to 8 megabytes of 150 nsec DRAM providing CPU access to memory with no wait states.<br>• NS32016 CPU runs at 10 MHz.<br>• Four RS232 compatible serial ports.<br>• Centronics compatible parallel port.<br>• Small Computer System Interface (SCSI).<br>• "Minibus" expansion bus for interfacing special purpose modules. | NS32016-CPU<br>NS32201-TCU<br>NS32082-MMU<br>NS32081-FPU<br>NS32202-ICU | |
| Memory boards for ICM-3216<br>ICM-3216-1MEM (1 Mbyte)<br>ICM-3216-2MEM (2 Mbyte)<br>ICM-3216-4MEM (4 Mbyte) | The ICM-3216 memory board contains the dynamic RAM for the ICM-3216 Integrated Computer Module. Up to two memory boards can be configured with CPU unit to provide between one and eight million bytes of memory. The memory board(s) interface to the CPU unit via a "Direct Connect" local memory bus. The system operates at 10 MHz with no wait states for normal memory access. | | Up to 8 Mbytes with additional Memory Boards |
| ICM-3216 Operating System System V.2/Series 32000<br>ICM016-1UNV2MBT | System V.2/Series 32000 has been ported to this system. System V.2/Series 32000 is a validated port of UNIX System V Release 2.0 Version 2. This operating system provides optimal use of the Series 32000 architecture. It supports demand-paged virtual memory and offers Job Control as well as File and Record Locking. "C" and FORTRAN compilers, the Series 32000 assembler and all 32000 language support tools are provided. Reconfigurable binary drivers have been written for rigid disk, streaming tape, serial ports and parallel port. | | |
| ICM R&D Kits for ICM-3216 System<br>ICM-3216-RD-1 (1 Mbyte)<br>ICM-3216-RD-4 (4 Mbyte) | The ICM-3216-RD-1 and RD-4 kits provide the user with a 1 Mbyte or 4 Mbyte ICM-3216 board level system. The ICM-3216 system includes the System V/Series 32000 Operating System (a validated port of UNIX System V Version 2), the license required to operate this OS, a complete set of manuals and the necessary cabling between components.<br>• Requires the addition of controllers, disk and tape drives, power supply and terminal to configure a minimum system.<br>• System V/Series 32000 binary users license must be in place prior to shipment of package. | ICM-3216 R&D Kit includes:<br>CPU Board ICM-3216<br>Memory Board ICM-3216-1MEM or ICM-3216-4MEM<br>GENIX V.2 ICM016-1UNV2MBT<br>Monitor EPROM -ICM-3216-MON<br>Manuals/Adaptors/Cables | |

## Series 32000 Development Products (Continued)

| Device | Description | Devices Supported | Memory Capacity |
|---|---|---|---|
| Serial Input/Output Board (SIO)<br>ICM-SIO-M-8 | The Serial Input/Output (SIO) board is designed for use with any ICM system. In a typical system, the primary (host) CPU must handle a number of terminals simultaneously, which can limit the amount of productive work that the host can perform. The Serial I/O board relieves the host of much of this task by supplying the system on board intelligence required to service the eight full-duplex asynchronous communication lines.<br>By incorporating an NS32016 CPU, 256 Kbytes of DRAM and 32 to 128 Kbytes of EPROM on board, the SIO board is able to handle most of the overhead associated with the terminal handling task, leaving the host CPU free to devote itself to more productive work.<br>• NS32016 CPU<br>• 256 Kbytes of Random Access Memory with bytes parity<br>• EPROM sockets for 32K to 128K bytes of EPROM<br>• Eight asynchronous RS232C compatible serial ports<br>• Serial communication rates of up to 19.2 Kbaud<br>• Four general purpose timers<br>• Interface to Host System via Minibus<br>• S/W driver available to run this board under GENIX V.2 or V.3. | NS32016-CPU | |
| **Ancillary Hardware** | | | |
| Firmware Monitor<br>ICM-3216-MON or ICM-332-1MON | Monitor EPROM set. The EPROM monitors provide the capability of executing most common monitor commands as well as the ability to boot the operating system. | | |
| Minibus I/O Interface<br>ICM-MBIC-C | MiniBus is a high performance 16-bit bus, which will support intelligent bus masters while at the same time maintaining a simple bus interface for non-intelligent I/O boards. The MiniBus Interface Controller (MBIC), a custom VLSI interface chip has been developed to provide a single chip bus interface which provides full bus compatibility. This interface chip is available to the user who wishes to design an intelligent special purpose module to interface with the system via MiniBus. | | |
| ICM-CBL-TELCO | Cable, Telco, 6-wire, 7 feet. | | |
| ICM-CON-FEM | Adaptor, Telco to DB25 to Female connector. | | |
| ICM-CON-MAL | Adaptor, Telco to DB25 to Male connector. | | |
| ICM-POWER-KIT | All necessary connectors to connect a power supply to an ICM system. | | |
| ICM-DESIGN-KIT | All of the custom connector parts needed for the designer to build special purpose modules for an ICM system. | | |
| **Future ICM Products** | | | |
| | Functions such as Local Area Network controllers, Graphics controller, X.25 interface and others will be available in the near future. Contact NSC for availability. | | |

## Series 32000 Software

| Device | Description | Host Systems |
|---|---|---|
| **GENIX Operating Systems and Language Tools** | | |
| GENIX 4.1/4.2 Operating System | AT&T licensed Source of Berkeley UNIX Operating System for multi-tasking, multi-user Series 32000 Software development. GENIX 4.1 includes C Compiler and demand-paged virtual memory (Pascal optional). GENIX 4.2 also provides fast file system and local area networking. Order as NSW-GENIX-XXXX. | VAX™/UNIX (GENIX 4.1)<br>VAX/VMS (GENIX 4.2) |
| SYSTEM V/Series 32000 V.2 | Validated port of AT&T UNIX System V.2 Operating System. Multi-tasking, multi-user environment providing demand-paged virtual memory, file and record locking capabilities; C and FORTRAN 77 compilers included. Order as NSW-SYSV-XXXX. | SYS 32/XX<br>VR 32<br>ICM 3216<br>VAX/UNIX |
| GENIX V.3 Operating System | Certified port of AT&T UNIX System V.3 Operating System providing features of V.2 plus shared libraries and networking capabilities; C and FORTRAN 77 compilers included. Order as NSW-GV3-XXXX. | SYS 32/XX<br>VR 32<br>ICM 32XX<br>VAX/UNIX |
| GNX Tools | A set of Language Tools packaged for native and cross environments.<br>*ASSEMBLER* includes assembler, linkers, libraries, debuggers, monitors, etc. for development of Series 32000 code. This is the prerequisite for related compilers. Order as NSW-ASM-XXXX.<br>*C COMPILER* used with Assembler to do Series 32000 code development. Order as NSW-C-XXXX.<br>*FORTRAN 77 COMPILER* used with Assembler to do Series 32000 code development. Order as NSW-F77-XXXX.<br>*PASCAL COMPILER* used with Assembler to do Series 32000 code development. Order as NSW-PAS-XXXX. | SYS 32/XX<br>VR 32<br>ICM 3216<br>VAX/UNIX<br>VAX/VMS<br>(for all GNX packages) |
| **Real Time Operating Systems and Support Tools** | | |
| EXEC | Multi-tasking ROMable executive for real-time applications. Runs on all Series 32000 CPUs. Complete Source code package gives hardware independence and is fully user-configurable. Order as NSW-EXEC-XXXX. | SYS 32/XX<br>VR 32<br>VAX/UNIX<br>VAX/VMS |
| VRTX/Real-Time Products | A collection of products for embedded real-time applications.<br>*VRTX* Kernel manages the multi-tasking environment and responds to Operating System service requests. This is the prerequisite for all other VRTX-related packages. Order as NSW-VRTX-XXXX.<br>*TRACER* is an interactive multi-tasking debugger matched to the VRTX Kernel. TRACER displays and modifies VRTX system data structures. Order as NSW-TRAC-XXXX.<br>*SUPPORT LIBRARIES* includes re-entrant C Run-Time Support library; interface libararies for C and Pascal. Order as NSW-VIL-XXXX.<br>*BOARD SUPPORT PACKAGE* provides initialization and configuration routines to bring up VRTX and TRACER on several Series 32000 boards. | SYS 32/XX<br>ICM 32XX<br>VAX/UNIX<br>VAX/VMS |

## Series 32000 Software Products By Part Number

### UNIX-Derived Operating Systems

| | |
|---|---|
| NSW-GENIX-1SGC | GENIX 4.1 Source pkg for use on SYS 32/10 host. |
| NSW-GENIX-1VXR | GENIX 4.1 Source pkg for use on VAX/UNIX 4.1 host. |
| NSW-GENIX-2VXR | GENIX 4.2 Source pkg for use on VAX/UNIX 4.2 host. |
| NSW-GENIX-4VXR | GENIX 4.1 Source pkg for use on VAX/UNIX 4.2 host. |
| NSW-SYSV-BCTF | SYSTEM V.2 Binary pkg for use on ICM 3216 host. |
| NSW-SYSV-BCTF8 | SYSTEM V.2 Binary driver for 4-12 user addition for use on ICM 3216; NSW-SYSV-BCTF prereq. |
| NSW-SYSV-BHAF | SYSTEM V.2 Binary pkg for SYS 32/20 host; high density diskettes. |
| NSW-SYSV-BLAF | SYSTEM V.2 Binary pkg for SYS 32/20 host; low density diskettes. |
| NSW-SYSV-SCTF | SYSTEM V.2 Source pkg for ICM 3216 host. |
| NSW-SYSV-2VFR | SYSTEM V.2 Source pkg for VAX/UNIX host. |
| NSW-GV3-SCNX | SYSTEM V.3 Source pkg for UNIX-based host, cartridge tape. |
| NSW-GV3-SRNX | SYSTEM V.3 Source pkg for UNIX-based host, reel tape. |
| NSW-GV3-BCTF | SYSTEM V.3 Binary pkg for use on ICM 3216 host. |

### UNIX-Derived Language Tools (GNX Tools)

| | |
|---|---|
| NSW-ASM-BCTF | GNX Assembler Binary pkg including assembler, debuggers, monitors, and utilities for ICM 3216 host. |
| NSW-C-BCTF | GN C Compiler Binary pkg for ICM 3216 host. |
| NSW-F77-BCTF | GNX FORTRAN 77 Binary pkg for ICM 3216 host. |
| NSW-PAS-BCTF | GNX Pascal Binary pkg for ICM 3216 host. |
| NSW-ASM-BHAF | GNX Assembler Binary pkg including assembler, debuggers, monitors, and utilities for SYS 32/20 host; high density diskettes. |
| NSW-ASM-BLAF | GNX Assembler Binary pkg including assembler, debuggers, monitors, and utilities for SYS 32/20 host; low density diskettes. |
| NSW-C-BLAF | GNX C Compiler Binary pkg for SYS 32/20 host; low density diskettes. |
| NSW-F77 BLAF | GNX FORTRAN 77 Binary pkg for SYS 32/20 host; low density diskettes. |
| NSW-PAS-BLAF | GNX Pascal Binary pkg for SYS 32/20 host; low density diskettes. |
| NSW-ASM-BRVM | GNX Assembler Binary pkg including assembler, debuggers, monitors, and utilities for VAX/VMS host. |
| NSW-C-BRVM | GNX C Compiler Binary pkg for VAX/VMS host. |
| NSW-F77-BRVM | GNX FORTRAN 77 Binary pkg for VAX/VMS host. |
| NSW-PAS-BRVM | GNX Pascal Binary pkg for VAX/VMS host. |
| NSW-ASM-BRVX | GNX Assembler Binary pkg including assembler, debuggers, monitors, and utilities for VAX/UNIX 4.2 bsd host. |
| NSW-C-BRVX | GNX C Compiler Binary pkg for VAX/UNIX 4.2 bsd host. |
| NSW-F77-BRVX | GNX FORTRAN 77 Binary pkg for VAX/UNIX 4.2 bsd host. |
| NSW-PAS-BRVX | GNX Pascal Binary pkg for VAX/UNIX 4.2 bsd host. |
| NSW-ASM-SRNN | GNX Assembler Source pkg for use on VAX/UNIX 4.2 host. |
| NSW-C-SRNN | GNX C Compiler Source pkg for use on VAX/UNIX 4.2 host. |
| NSW-F77-SRNN | GNX FORTRAN 77 Source pkg for use on VAX/UNIX 4.2 host. |
| NSW-PAS-SRNN | GNX Pascal Source pkg for use on VAX/UNIX 4.2 host. |
| NSS-SYS32-3001 | Pascal Compiler Binary pkg for SYS 32/10 host. |
| NSS-VR32-3001 | Pascal Compiler Binary pkg for VR 32 host. |

## Series 32000 Software Products By Part Number (Continued)

**Real-Time Operating Systems and Tools**

| | |
|---|---|
| NSW-EXEC-SCSG | Exec Real-time Operating System Source pkg for SYS 32 host. |
| NSW-EXEC-SDQF | Exec Real-time Operating System Source pkg for VR 32 host. |
| NSW-EXEC-SRVM | Exec Real-time Operating System Source pkg for VAX/VMS host. |
| NSW-EXEC-SRVX | Exec Real-time Operating System Source pkg for VAX/UNIX 4.2 host. |
| NSW-VRTX-BENN | VRTX R and D pkg for EPROM; binary. |
| NSW-VRTX-BRVM | VRTX R and D pkg for VAX/VMS host; binary. |
| NSW-VRTX-BRVX | VRTX R and D pkg for VAX/UNIX 4.2 host; binary. |
| NSW-VRTX-BLAF | VRTX R and D pkg for SYS 32/20 host; low density diskettes; binary. |
| NSW-VRTX-BCTF | VRTX R and D pkg for ICM 3216 host; binary. |
| NSW-VRTX-SPNN | VRTX R and D pkg; Source paper. |
| NSW-TRAC-BENN | TRACER R and D pkg for EPROM; binary. |
| NSW-TRAC-BRVM | TRACER R and D pkg for VAX/VMS; binary. |
| NSW-TRAC-BRVX | TRACER R and D pkg for VAX/UNIX 4.2; binary. |
| NSW-TRAC-BLAF | TRACER R and D pkg for SYS 32/20 host; low density diskettes; binary. |
| NSW-TRAC-BCTF | TRACER R and D pkg for ICM 3216 host; binary. |
| NSW-TRAC-SPNN | TRACER R and D pkg; Source paper. |
| NSW-VBSP-SRVM | VRTX Board Support Package for VAX/VMS; Source. |
| NSW-VBSP-SRVX | VTRX Board Support Package for VAX/UNIX 4.2; Source. |
| NSW-VBSP-SCTF | VRTX Board Support Package for ICM 3216; Source. |
| NSW-VBSP-SLAF | VRTX Board Support Package for SYS 32/20; Source; low density diskettes. |
| NSW-VIL-SRVM | VRTX C/Pascal Interface libraries for VAX/VMS; Source. |
| NSW-VIL-SRVX | VRTX C/Pascal Interface libraries for VAX/UNIX 4.2; Source. |
| NSW-VIL-SLAF | VRTX C/Pascal Interface libraries for SYS 32/20; Source; low density diskettes. |
| NSW-VIL-SCTF | VRTX C/Pascal Interface libraries for ICM 3216; Source. |

# Microprocessors 8-Bit

The NSC800 family offers high-performance CMOS 8-bit microprocessor using National's microCMOS process.

The NSC800 CPU features 158 instructions, minimum instruction execution time of 1 μs (4 MHz version), and power consumption of 75 mW (@4 MHz). In addition, various support chips are provided so that high-speed CMOS systems can easily be created.

Leadless chip carriers (LCC) and plastic chip carriers (PCC) are mass-produced to improve the component packaging efficiency of systems.

## Features

- Fully compatible Z80® instruction set: 158 instructions, 10 address modes, 22 internal registers
- Wide power supply range—2.4V to 6.0V
- Addresses up to 64k bytes of memory and 256 I/O devices
- Low power: 50 mW @ 5V $V_{CC}$ with unique power save feature
- Multiplex bus structure
- 5 interrupt request lines on-chip

## NSC800 Family Chips

| Device Number | Description | Temperature Range (°C) | Packaging Information |
|---|---|---|---|
| NSC800-3 | microCMOS 8 CPU 2.5 MHz | * | D40, N40 |
| NSC800-1 | microCMOS 8 CPU 1.0 MHz | * | E44, V44 |
| NSC800-4 | microCMOS 8 CPU 4.0 MHz | * | |
| NSC810A-3 | microCMOS RAM I/O Expander 2.5 MHz | * | D40, N40 |
| NSC810A-1 | microCMOS RAM I/O Expander 1.0 MHz | * | E44, V44 |
| NSC810A-4 | microCMOS RAM I/O Expander 4.0 MHz | * | |
| NSC831-3 | microCMOS Parallel I/O Expander 2.5 MHz | * | D40, N40 |
| NSC831-1 | microCMOS Parallel I/O Expander 1.0 MHz | * | E44 |
| NSC831-4 | microCMOS Parallel I/O Expander 4.0 MHz | * | |
| NSC858 | microCMOS UART | − 55 to + 125 | N28, V44 |
| NSC888 | NSC800-Evaluation Board | | Board |

*Temperature ranges available (°C)
− 55°C to + 125°C
− 40°C to + 85°C
0°C to + 70°C

# Programmable Logic

For additional Programmable Logic products, see page 345.

# Programmable Logic

The nature of logic design continues to change, and National Semiconductor is leading the change into software-based logic and systems design with the availability of programmable logic devices. These devices offer powerful capabilities for creating cost-effective new products or for improving the efficiencies of existing logic designs.

National's commitment to the design, development and support of this technology is exemplified by the extensive and continually expanding line of the PAL® devices offered to the user today.

Available in a vast range of speed/power configurations, package types and technologies (bipolar, ECL and CMOS), you can easily select the device which best meets the needs of your design.

**Programmable Logic Part Number System**

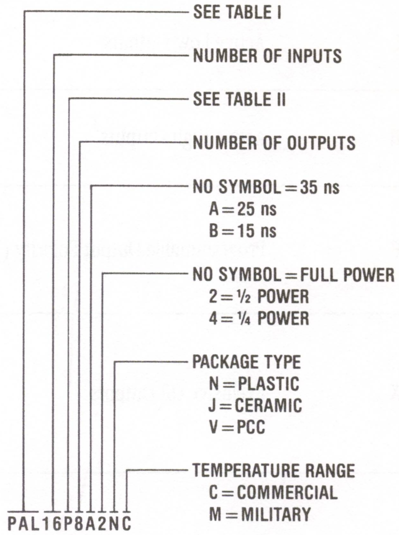
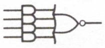
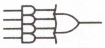
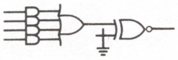
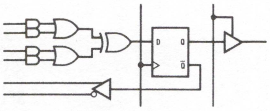
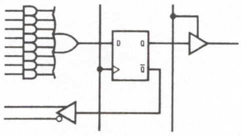
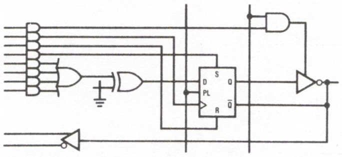
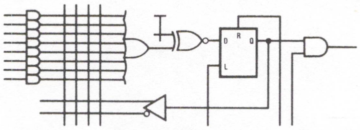
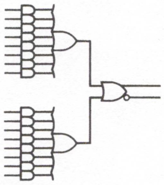

SEE TABLE I
NUMBER OF INPUTS
SEE TABLE II
NUMBER OF OUTPUTS
NO SYMBOL = 35 ns
A = 25 ns
B = 15 ns
NO SYMBOL = FULL POWER
2 = ½ POWER
4 = ¼ POWER
PACKAGE TYPE
N = PLASTIC
J = CERAMIC
V = PCC
TEMPERATURE RANGE
C = COMMERCIAL
M = MILITARY
PAL16P8A2NC

**Table 1**

| Symbol | Meaning |
|---|---|
| PAL | TTL Field Programmable PAL IC |
| PL | Factory Programmed PAL IC |
| PALC | CMOS Programmable Logic Device |
| NL | National Masked Logic (NML) |
| PAL 10 | 10KH Compatible ECL |
| PAL 100 | 100K Compatible ECL |

**Table II**

| Symbol | Meaning | Configuration |
|---|---|---|
| L | Active Low Outputs |  |
| H | Active High Outputs |  |
| P | Programmable Output Polarity (TTL and CMOS) |  |
| X | Exclusive OR Outputs |  |
| R | Synchronous Registered Outputs |  |
| A | Asynchronous Registered Outputs |  |
| L | Latched Outputs (ECL Only) |  |
| C | Complementary Outputs |  |

## PAL Device Cross Reference

| | NSC | Comm. $t_{PD}$ | $I_{CC}$ | Military $t_{PD}$ | Product Term Allocation (Outputs × P.T./Output) | Programmable I/O | Registers |
|---|---|---|---|---|---|---|---|
| 20-Pin Small | PAL10H8 | 35 ns | 90 mA | 45 | 8 × 2 | | |
| | PAL10L8 | 35 ns | 90 mA | 45 | 8 × 2 | | |
| | PAL12H6 | 35 ns | 90 mA | 45 | 4, 4 × 2, 4 | | |
| | PAL12L6 | 35 ns | 90 mA | 45 | 4, 4 × 2, 4 | | |
| | PAL14H4 | 35 ns | 90 mA | 45 | 4 × 4 | | |
| | PAL14L4 | 35 ns | 90 mA | 45 | 4 × 4 | | |
| | PAL16H2 | 35 ns | 90 mA | 45 | 2 × 8 | | |
| | PAL16L2 | 35 ns | 90 mA | 45 | 2 × 8 | | |
| | PAL16C1 | 40 ns | 90 mA | 45 | 16 | | |
| 20-Pin Fast Small | PAL10H8A | 25 ns | 90 mA | 30 | 8 × 2 | | |
| | PAL10L8A | 25 ns | 90 mA | 30 | 8 × 2 | | |
| | PAL12H6A | 25 ns | 90 mA | 30 | 4, 4 × 2, 4 | | |
| | PAL12L6A | 25 ns | 90 mA | 30 | 4, 4 × 2, 4 | | |
| | PAL14H4A | 25 ns | 90 mA | 30 | 4 × 4 | | |
| | PAL14L4A | 25 ns | 90 mA | 30 | 4 × 4 | | |
| | PAL16H2A | 25 ns | 90 mA | 30 | 2 × 8 | | |
| | PAL16L2A | 25 ns | 90 mA | 30 | 2 × 8 | | |
| | PAL16C1A | 30 ns | 90 mA | 30 | 16 | | |
| 20-Pin Small 1/2 Power | PAL10H8A2 | 35 ns | 45 mA | 45 | 8 × 2 | | |
| | PAL10L8A2 | 35 ns | 45 mA | 45 | 8 × 2 | | |
| | PAL12H6A2 | 35 ns | 45 mA | 45 | 4, 4 × 2, 4 | | |
| | PAL12L6A2 | 35 ns | 45 mA | 45 | 4, 4 × 2, 4 | | |
| | PAL14H4A2 | 35 ns | 45 mA | 45 | 4 × 4 | | |
| | PAL14L4A2 | 35 ns | 45 mA | 45 | 4 × 4 | | |
| | PAL16H2A2 | 35 ns | 45 mA | 45 | 2 × 8 | | |
| | PAL16L2A2 | 35 ns | 45 mA | 45 | 2 × 8 | | |
| | PAL16C1A2 | 40 ns | 45 mA | 45 | 16 | | |
| 20-Pin Medium | PAL16L8 | 35 ns | 180 mA | 45 | 8 × 7 | 6 | |
| | PAL16R4 | 35 ns | 180 mA | 45 | 2 × 7, 4 × 8, 2 × 7 | 4 | 4 |
| | PAL16R6 | 35 ns | 180 mA | 45 | 7, 6 × 8, 7 | 2 | 6 |
| | PAL16R8 | 35 ns | 180 mA | 45 | 8 × 8 | | 8 |
| 20-Pin Fast Medium | PAL16L8A | 25 ns | 180 mA | 30 | 8 × 7 | 6 | |
| | PAL16R4A | 25 ns | 180 mA | 30 | 2 × 7, 4 × 8, 2 × 7 | 4 | 4 |
| | PAL16R6A | 25 ns | 180 mA | 30 | 7, 6 × 8, 7 | 2 | 6 |
| | PAL16R8A | 25 ns | 180 mA | 30 | 8 × 8 | | 8 |
| 20-Pin Ultra-Fast Medium | PAL16L8B | 15 ns | 180 mA | 20 | 8 × 7 | 6 | |
| | PAL16R4B | 15 ns | 180 mA | 20 | 2 × 7, 4 × 8, 2 × 7 | 4 | 4 |
| | PAL16R6B | 15 ns | 180 mA | 20 | 7, 6 × 8, 7 | 2 | 6 |
| | PAL16R8B | 15 ns | 180 mA | 20 | 8 × 8 | | 8 |
| 20-Pin Fast Medium with Programmable Polarity | PAL16P8A | 25 ns | 180 mA | 30 | 8 × 7 | 6 | |
| | PAL16RP4A | 25 ns | 180 mA | 30 | 2 × 7, 4 × 8, 2 × 7 | 4 | 4 |
| | PAL16RP6A | 25 ns | 180 mA | 30 | 7, 6 × 8, 7 | 2 | 6 |
| | PAL16RP8A | 25 ns | 180 mA | 30 | 8 × 8 | | 8 |

## PAL Device Cross Reference

| | NSC | Comm. $t_{PD}$ | $I_{CC}$ | Military $t_{PD}$ | Product Term Allocation (Outputs × P.T./Output) | Programmable I/O | Registers |
|---|---|---|---|---|---|---|---|
| 20-Pin Medium 1/2 Power | PAL16L8A2 | 35 ns | 90 mA | 50 | 8 × 7 | 6 | |
| | PAL16R4A2 | 35 ns | 90 mA | 50 | 2 × 7, 4 × 8, 2 × 7 | 4 | 4 |
| | PAL16R6A2 | 35 ns | 90 mA | 50 | 7, 6 × 8, 7 | 2 | 6 |
| | PAL16R8A2 | 35 ns | 90 mA | 50 | 8 × 8 | | 8 |
| 20-Pin Ultra-Fast Medium 1/2 Power | PAL16L8B2 | 25 ns | 90 mA | 30 | 8 × 7 | 6 | |
| | PAL16R4B2 | 25 ns | 90 mA | 30 | 2 × 7, 4 × 8, 2 × 7 | 4 | 4 |
| | PAL16R6B2 | 25 ns | 90 mA | 30 | 7, 6 × 8, 7 | 2 | 6 |
| | PAL16R8B2 | 25 ns | 90 mA | 30 | 8 × 8 | | 8 |
| 24-Pin Small | PAL12L10 | 40 ns | 100 mA | 45 | 10 × 2 | | |
| | PAL14L8 | 40 ns | 100 mA | 45 | 4, 6 × 2, 4 | | |
| | PAL16L6 | 40 ns | 100 mA | 45 | 2 × 4, 2 × 2, 2 × 4 | | |
| | PAL18L4 | 40 ns | 100 mA | 45 | 6, 2 × 4, 6 | | |
| | PAL20L2 | 40 ns | 100 mA | 45 | 2 × 8 | | |
| | PAL20C1 | 40 ns | 100 mA | 45 | 16 | | |
| 24-Pin Medium | PAL20L10 | 50 ns | 165 mA | 60 | 10 × 3 | 8 | |
| | PAL20X4 | 50 ns | 180 mA | 60 | 3 × 3, 4 × 2, 3 × 3 | | 4 |
| | PAL20X8 | 50 ns | 180 mA | 60 | 3, 8 × 2, 3 | | 8 |
| | PAL20X10 | 50 ns | 180 mA | 60 | 10 × 2 | | 10 |
| 24-Pin Fast Medium | PAL20L8A | 25 ns | 210 mA | 30 | 8 × 7 | 6 | |
| | PAL20R4A | 25 ns | 210 mA | 30 | 2 × 7, 4 × 8, 2 × 7 | 4 | 4 |
| | PAL20R6A | 25 ns | 210 mA | 30 | 7, 6 × 8, 7 | 2 | 6 |
| | PAL20R8A | 25 ns | 210 mA | 30 | 8 × 8 | | 8 |
| 24-Pin Ultra-Fast Medium | PAL20L8B | 15 ns | 210 mA | 20 | 8 × 7 | 6 | |
| | PAL20R4B | 15 ns | 210 mA | 20 | 2 × 7, 4 × 8, 2 × 7 | 4 | 4 |
| | PAL20R6B | 15 ns | 210 mA | 20 | 7, 6 × 8, 7 | 2 | 6 |
| | PAL20R8B | 15 ns | 210 mA | 20 | 8 × 8 | | 8 |
| 24-Pin Ultra-Fast Medium with Programmable Polarity | PAL20P8B | 15 ns | 210 mA | 20 | 8 × 7 | 6 | |
| | PAL20RP4B | 15 ns | 210 mA | 20 | 2 × 7, 4 × 8, 2 × 7 | 4 | 4 |
| | PAL20RP6B | 15 ns | 210 mA | 20 | 7, 6 × 8, 7 | 2 | 6 |
| | PAL20RP8B | 15 ns | 210 mA | 20 | 8 × 8 | | 8 |
| 24-Pin Registered Asynchronous | PAL20RA10 | 35 ns | 200 mA | 40 | 10 × 4 | 10 | 10 |
| ECL PAL Devices | **PAL1016P8 | 6 ns | 220 mA | N/A | 8 × 8 | | 8 |
| | PAL1016RC8 | 6 ns | 220 mA | N/A | 8 × 8 | | 8 |
| | PAL1016RD8 | 6 ns | 220 mA | N/A | 8 × 8 | | 4 |
| | PAL1016RC4 | 6 ns | 220 mA | N/A | 8 × 8 | | 4 |
| | PAL1016RD4 | 6 ns | 220 mA | N/A | 8 × 8 | | 4 |
| | PAL1016LC8 | 6 ns | 220 mA | N/A | 8 × 8 | | 8 Latches |
| | PAL1016LD8 | 6 ns | 220 mA | N/A | 8 × 8 | | 8 Latches |
| | PAL1016LC4 | 6 ns | 220 mA | N/A | 8 × 8 | | 4 Latches |
| | PAL1016LD4 | 6 ns | 220 mA | N/A | 8 × 8 | | 4 Latches |

**This family offers both 10KH and 100K logic compatible devices.

All TTL PAL devices available in: N (Molded DIP), J (Ceramic DIP) and V (Plastic Leaded Chip Carrier). ECL PAL devices available in: J (Ceramic DIP), W (Ceramic Flat Package) and E (Leadless Chip Carrier).

# Telecommunications

For additional Telecommunications products, see page 349.

# Telecommunications

To coincide with the advent of the Integrated Services Digital Network (ISDN), this guide portrays the continuing evolution of the telecommunications network and the integrated circuit technology required to support it. This guide shows the emergence of a fully digital network, including high capacity public and private digital loops to implement greater worldwide communications capability and flexibility. The integrated circuits required for today's telecommunications technology are no longer simple functions, but are complete systems. With unprecedented functionality and parametric performance levels, they utilize the most advanced silicon process technology available. This guide contains a complete product listing of all ''dedicated'' telecommunications components for the system designer. Full data sheets on these devices are available upon request.

Shipping over 5 million subscriber or trunk lines per year, National Semiconductor is an industry leader in the field of telecommunications specific integrated circuit functions. In 1977, the introduction of the world's first commercially available integrated codec, the TP3000, led the way to the worlds' first industry standard single chip codec/filter COMBO™, the TP3054/57. In 1986, the announcement of the TP3070 COMBO II™ proved National's ability to provide state-of-the-art high performance and cost effectiveness. Other line card component developments, such as the Digital Line Interface Controller (DLIC), parallel COMBO, Magnetic Compensation SLIC MC, Time Slot Assigner Circuit (TSAC), and now ISDN are clear signs of National's dedication and long term committment to the market.

National Semiconductor will continue to monitor the evolving requirements in telecommunications industry applications. New IC designs will provide additional features and further improve cost effectiveness. Systems designers can utilize the most advanced technology available with National's telecommunications integrated circuits. National further assures success by designing products which have the highest quality and reliability standards in the world.

# Telecommunications Selection Guide

## Digital Switching Components

| | |
|---|---|
| TP3020 | Monolithic CODEC |
| TP3020-1 | Monolithic CODEC |
| TP3021 | Monolithic CODEC |
| TP3021-1 | Monolithic CODEC |
| TP3040 | PCM Monolithic Filter |
| TP3040-1 | PCM Monolithic Filter |
| TP3040A-1 | PCM Monolithic Filter |
| TP3051 | Monolithic Parallel Data Interface CMOS CODEC/Filter Combo |
| TP3052 | Monolithic Serial Interface CMOS CODEC/Filter Combo |
| TP3053 | Monolithic Serial Interface CMOS CODEC/Filter Combo |
| TP3054 | Monolithic Serial Interface CMOS CODEC/Filter Combo |
| TP3056 | Monolithic Parallel Data Interface CMOS CODEC/Filter Combo |
| TP3057 | Monolithic Serial Interface CMOS CODEC/Filter Combo |
| TP3064 | Monolithic Serial Interface CMOS CODEC/Filter Combo with Dual Power Amps |
| TP3067 | Monolithic Serial Interface CMOS CODEC/Filter Combo with Dual Power Amps |
| TP3110 | Digital Line Interface Controller (DLIC) |
| TP3120 | Digital Line Interface Controller (DLIC) |
| TP3155 | Time Slot Assignment Circuit |
| TP3200 | SLIC-MC Magnetic Compensation SLIC |
| TP3201 | SLIC-MC Magnetic Compensation SLIC |
| TP5116A | Monolithic CODEC |
| TP5156A | Monolithic CODEC |

## Telephone Set Components

| | |
|---|---|
| TP5087 | DTMF (TOUCH-TONE®) Generator |
| TP5088 | DTMF Generator for Binary Data |
| TP5089 | DTMF (TOUCH-TONE) Generator |
| TP5700 | Telephone Speech Circuit |
| TP5700-1 | Telephone Speech Circuit |
| TP5710 | Telephone Speech Circuit |

## Modems

| | |
|---|---|
| MM74HC942 | 300 Baud Modem (+5V, −5V Supply) |
| MM74HC943 | 300 Baud Modem (5V Supply) |
| TP3310 | Monolithic Reversible 1200-600/150-75-5 Bit/s CMOS FSK Modem |
| TP3311 | Monolithic Reversible 1200-600/150-75-5 Bit/s CMOS FSK Modem |
| TP3320 | Monolithic Reversible 1200-600/150-75-5 Bit/s CMOS FSK Modem |
| TP3321 | Monolithic Reversible 1200-600/150-75-5 Bit/s CMOS FSK Modem |

# Telecommunications Selection Guide

|  |  | TP3051 | TP3052 | TP3053 | TP3054 | TP3056 | TP3057 | TP3058 | TP3059 | TP3064 | TP3067 | TP3054X | TP3057X | TP3020 | TP3021 | TP5116 | TP5156 | TP3040 | TP3120 | TP3155 | TP5088 | TP5089 | TP5700 | TP3330 | MM74HC942 | MM74HC943 | TP3070 | TP3200 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Combined CODEC/ Filter Combos | μ-Law | ● | ● | ● | ● |  |  | ● |  | ● |  | ● |  | ● |  | ● |  |  |  |  |  |  |  |  |  |  | ● |  |
|  | A-Law |  |  |  |  | ● | ● |  | ● |  | ● |  | ● |  | ● |  | ● |  |  |  |  |  |  |  |  |  | ● |  |
|  | Serial PCM Bus |  | ● | ● | ● |  | ● |  |  | ● | ● | ● | ● | ● | ● | ● | ● |  |  |  |  |  |  |  |  |  | ● |  |
|  | Parallel PCM Bus | ● |  |  |  | ● |  | ● | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Receive Power Amps |  |  |  |  |  |  |  |  | ● | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |
|  | Signaling, Short Frame |  | ● |  | ● |  |  |  |  |  |  |  |  | ● | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Signaling, Long Frame |  |  | ● |  |  |  |  |  |  |  |  |  |  |  | ● | ● |  |  |  |  |  |  |  |  |  |  |  |
|  | −40 to +85°C |  |  |  |  |  |  |  |  |  |  | ● | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | μP Compatible |  |  |  |  |  |  | ● | ● |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |
|  | Programmable Gains |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |
|  | Programmable Hybrid Balance |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |
|  | Programmable SLIC Latches |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |
| Line Card Controller |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |
| Time Slot Assigner |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  | ● |  |
| PCM CODEC U-Law |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |
| PCM CODEC A-Law |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  | ● |  |  |  |  |  |  |  |  |  |  |  |
| PCM Filter |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |
| DTMF Generator w/Binary Input |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |
| DTMF Generator for Keypad Interface |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |
| Analog Telephone Network |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |
| 300 Baud Modem |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |
| 300 Baud Modem 5V Only |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |
| 1200 Baud Bell 212A/V.22 Modem |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |
| SLIC—Magnetic Compensation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |
| 14-Pin Package |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |
| 16-Pin Package |  |  |  |  | ● |  | ● |  |  |  |  | ● | ● |  |  | ● | ● | ● |  |  |  | ● | ● |  |  |  |  |  |
| 18-Pin Package |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 20-Pin Package |  | ● |  | ● |  | ● |  |  |  | ● | ● |  |  |  |  |  |  |  |  |  |  |  |  |  | ● | ● | ● | ● |
| 22-Pin Package |  |  |  |  |  |  |  | ● | ● |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  | ● |
| 24-Pin Package |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 28-Pin Package |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  | ● |  |  | ● |  |
| 40-Pin Package |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |

# Military/Aerospace

For additional information on Aerospace/Defense, see page 355.

# Military/Aerospace Programs from National Semiconductor

This section is intended to provide a brief overview of military products available from National Semiconductor. For further information, refer to our *1987 Reliability Handbook*.

## MIL-M-38510

The MIL-M-38510 Program, which is sometimes called the JAN IC Program, is administered by the Defense Electronics Supply Center (DESC). The purpose of this program is to provide the military community with standardized products that have been manufactured and screened to government-controlled specifications in government certified facilities. All 38510 manufacturers must be formally qualified and their products listed on DESC's Qualified Products List (QPL) before devices can be marked and shipped as JAN product.

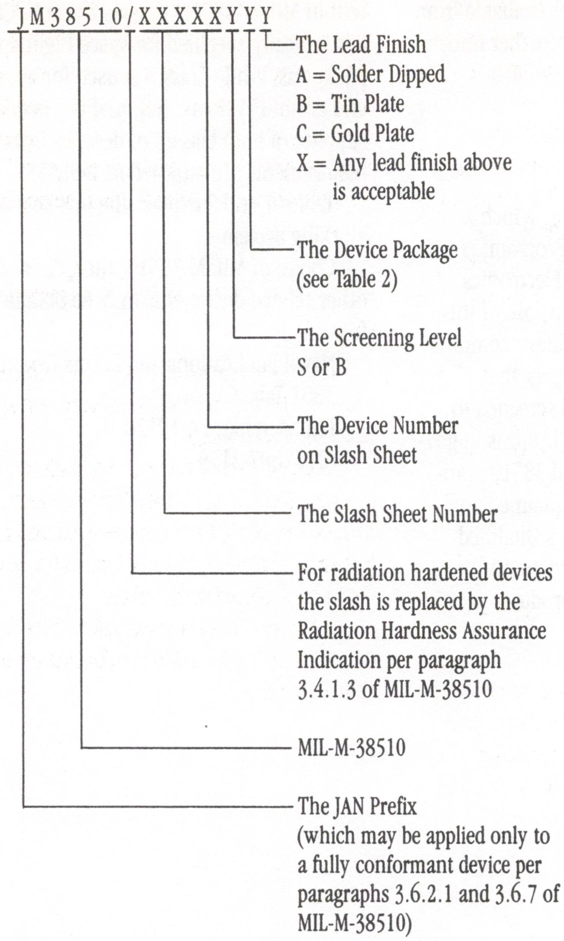
There are two processing levels specified within MIL-M-38510: Classes S and B. Class S is typically specified for space flight applications, while Class B is used for aircraft and ground systems. National is a major supplier of both classes of devices. Screening requirements are outlined in Table 3.

Tables 1 and 2 explain the JAN device marking system.

Copies of MIL-M-38510, the QPL, and other related documents may be obtained from:

Naval Publications and Forms Center
5801 Tabor Avenue
Philadelphia, PA 19120
(212) 697-2179

**Table 1. The MIL-M-38510 Part Marking**


JM38510/XXXXXYYY

The Lead Finish
A = Solder Dipped
B = Tin Plate
C = Gold Plate
X = Any lead finish above is acceptable

The Device Package (see Table 2)

The Screening Level S or B

The Device Number on Slash Sheet

The Slash Sheet Number

For radiation hardened devices the slash is replaced by the Radiation Hardness Assurance Indication per paragraph 3.4.1.3 of MIL-M-38510

MIL-M-38510

The JAN Prefix (which may be applied only to a fully conformant device per paragraphs 3.6.2.1 and 3.6.7 of MIL-M-38510)

**Table 2. JAN Package Codes**

| 38510 Package Designation | Microcircuit Industry Description |
|---|---|
| A | 14-pin 1/4″ × 1/4″ (metal) flat pack |
| B | 14-pin 3/15″ × 1/4″ flat pack |
| C | 14-pin 1/4″ × 3/4″ dual-in-line |
| D | 14-pin 1/4″ × 3/8″ (ceramic) flat pack |
| E | 16-pin 1/4″ × 7/8″ dual-in-line |
| F | 16-pin 1/4″ × 3/8″ (metal or ceramic) flat pack |
| G | 8-pin TO-99 can or header |
| H | 10-pin 1/4″ × 1/4″ (metal) flat pack |
| I | 10-pin TO-100 can or header |
| J | 24-pin 1/2″ × 1-1/4″ dual-in-line |
| K | 24-pin 3/8″ × 5/8″ flat pack |
| L | 24-pin 1/4″ × 1-1/4″ dual-in-line |
| M | 12-pin TO-101 can or header |
| N | Note 1 |
| P | 8-pin 1/4″ × 3/8″ dual-in-line |
| Q | 40-pin 3/16″ × 2-1/16″ dual-in-line |
| R | 20-pin 1/4″ × 1-1/16″ dual-in-line |
| S | 20-pin 1/4″ × 1/2″ flat pack |
| T | Note 1 |
| U | Note 1 |
| V | 18-pin 3/8″ × 15/16″ dual-in-line |
| W | 22-pin 3/8″ × 1-1/8″ dual-in-line |
| X | Note 1 |
| Y | Note 1 |
| Z | Note 1 |
| 2 | 20-terminal 0.350″ × 0.350″ chip carrier |
| 3 | 28-terminal 0.450″ × 0.450″ chip carrier |

Note 1: These letters are assigned to packages by individual MIL-M-38510 detail specifications and may be assigned to different packages in different specifications.

## DESC Specifications

DESC specifications are issued to provide standardized versions of devices which are not yet available as JAN product. MIL-STD-883 Class B screening is coupled with tightly controlled electrical specifications which have been written to allow a manufacturer to use his standard electrical tests. A current listing of National's DESC specification offerings can be obtained from our franchised distributors, sales representatives, or DESC. DESC is located in Dayton, Ohio.

## MIL-STD-883

Although originally intended to establish uniform test methods and procedures, MIL-STD-883 has also become the general specification for non-JAN military product. Revision C of this document defines the minimum requirements for a device to be marked and advertised as 883-compliant. Included are design and construction criteria, documentation controls, electrical and mechanical screening requirements, and quality control procedures. Details can be found in paragraph 1.2.1 of MIL-STD-883.

National offers both 883 Class B and 883 Class S product. The screening requirements for both classes of product are outlined in Table 3.

As with DESC specifications, a manufacturer is allowed to use his standard electrical tests provided that all critical parameters are tested. Also, the electrical test parameters, test conditions, test limits, and test temperatures must be clearly documented. At National Semiconductor, this information is available via our RETS (Reliability Electrical Test Specification Program). The RETS document is a complete description of the electrical tests performed and is controlled by our QA department. Individual copies are available upon request.

Some of National's older products are not completely compliant with MIL-STD-883, but are still required for use in military systems. These devices are screened to the same stringent requirements as 883 product, but are marked "-MIL".

## Military Screening Program (MSP)

National's Military Screening Program was developed to make screened versions of advanced products such as gate arrays and microprocessors available more quickly than is possible for JAN and 883 devices. Through this program, screened product is made available for prototypes and breadboards prior to or during the JAN or 883 qualification activities. MSP products receive the 100% screening of Table 3, but are not subjected to Group C and D quality conformance testing. Other criteria such as electrical testing and temperature range will vary depending upon individual device status and capability.

## Reliability Electrical Test Specifications (RETS™)

National has implemented the first real-time, electronic catalog of military test specifications called RETS.

Included in this computerized directory is a detailed listing of the electrical tests performed on all military devices qualified by National, including forcing functions, test limits and temperature ranges.

Call your local National sales office for essential up-to-the-minute information on device testing.

**Table 3. 100% Screening Requirements**

| | Class S | | Class B | |
|---|---|---|---|---|
| Screen | Method | Reqmt | Method | Reqmt |
| 1. Wafer Lot Acceptance | 5007 | All Lots | — | — |
| 2. Nondestructive Bond Pull (Note 14) | 2023 | 100% | — | — |
| 3. Internal Visual (Note 1) | 2020, Condition A | 100% | 2010, Condition B | 100% |
| 4. Stabilization Bake (Note 16) | 1008, Condition C, Min. 24 hrs. Min. | 100% | 1008, Condition C, Min., 24 hrs. Min. | 100% |
| 5. Temperature Cycling (Note 2) | 1010, Condition C | 100% | 1010, Condition C | 100% |
| 6. Constant Acceleration | 2001, Condition E Min. $Y_1$ Orientation Only | 100% | 2001, Condition E Min. $Y_1$ Orientation Only | 100% |
| 7. Visual Inspection (Note 3) | — | 100% | — | 100% |
| 8. Particle Impact Noise Detection (PIND) | 2010, Condition A (Note 4) | 100% | — | — |
| 9. Serialization | (Note 5) | 100% | — | — |
| 10. Interim (Pre-Burn-In) Electrical Parameters | Per Applicable Device Specification (Note 13) | 100% | Per Applicable Device Specification (Note 6) | — |
| 11. Burn-In Test | 1015<br>240 Hrs.@125°C Min.<br>(Cond. F Not Allowed) | 100% | 1015<br>160 Hrs.@125°C Min. | 100% |

## Table 3. 100% Screening Requirements

| | Class S | | Class B | |
|---|---|---|---|---|
| Screen | Method | Reqmt | Method | Reqmt |
| 12. Interim (Post Burn-In) Electrical Parameters | Per Applicable Device Specification (Note 13) | 100% | — | — |
| 13. Reverse Bias Burn-In (Note 7) | 1015; Test Condition A, C, 72 Hrs.@150°C Min. (Cond. F Not Allowed) | 100% | — | — |
| 14. Interim (Post-Burn-In) Electrical Parameters | Per Applicable Device Specification (Note 13) | 100% | Per Applicable Device Specification | 100% |
| 15. PDA Calculation | 5% Parametric (Note 14),<br>3% Functional | All Lots | 5% Parametric (Note 14) | All Lots |
| 16. Final Electrical Test (Note 15) | Per Applicable Device Specification | | Per Applicable Device Specification | |
| a) Static Tests | | | | |
| 1) 25°C (Subgroup 1, Table I, 5005) | | 100% | | 100% |
| 2) Max & Min Rated Operating Temp. (Subgroups 2, 3, Table I, 5005) | | 100% | | 100% |
| b) Dynamic Tests or Functional Tests | | | | |
| 1) 25°C (Subgroups 4 or 7) | | 100% | | 100% |
| 2) Max & Min Rated Operating Temp. (Subgroups 5 and 6 or 8, Table I, 5005) | | 100% | | 100% |
| c) Switching Tests 25°C (Subgroup 9 Table I, 5005) | | 100% | | 100% |
| 17. Seal Fine, Gross | 1014 | 100%, (Note 8) | 1014 | 100%, (Note 9) |
| 18. Radiographic (Note 10) | 2012 Two Views | 100% | — | — |
| 19. Qualification or Quality Conformance Inspection Test Sample Selection | (Note 11) | Samp. | (Note 11) | Samp. |
| 20. External Visual (Note 12) | 2009 | 100% | — | 100% |

Note 1: Unless otherwise specified, at the manufacturer's option, test samples for Group B, bond strength (Method 5005) may be randomly selected prior to or following internal visual (Method 5004), prior to sealing provided all other specification requirements are satisfied (e.g., bond strength requirements shall apply to each inspection lot, bond failures shall be counted even if the bond would have failed internal visual).

Note 2: For Class B devices, this test may be replaced with thermal shock method 1011, test condition A, minimum.

Note 3: At the manufacturer's option, visual inspection for catastrophic failures may be conducted after each of the thermal/mechanical screens, after the sequence or after seal test. Catastrophic failures are defined as missing leads, broken packages, or lids off.

Note 4: The PIND test may be performed in any sequence after step 6 and prior to step 16. See MIL-M-38510, paragraph 4.6.3.

Note 5: Class S devices shall be serialized prior to interim electrical parameter measurements.

Note 6: When specified, all devices shall be tested for those parameters requiring delta calculations.

Note 7: Reverse bias burn-in is a requirement only when specified in the applicable device specification. The order of performing burn-in and reverse bias burn-in may be inverted.

Note 8: For Class S devices, the seal test may be performed in any sequence between step 16 and step 19, but it shall be performed after all shearing and forming operations on the terminals.

Note 9: For Class B devices, the fine and gross seal tests shall be performed separately or together in any sequence and order between step 6 and step 20 except that they shall be performed after all shearing and forming operations on the terminals. When 100% seal screen cannot be performed after shearing and forming (e.g., flatpacks and chip carriers) the seal screen shall be done 100% prior to these operations and a sample test (LTPD = 5) shall be performed on each inspection lot following these operations. If the sample fails, 100% rescreening shall be required.

Note 10: The radiographic screen may be performed in any sequence after step 9.

Note 11: Samples shall be selected for testing in accordance with the specific device class and lot requirements of Method 5005.

Note 12: External Visual shall be performed on the lot any time after step 19 and prior to shipment.

Note 13: Read and record is required at steps 10 and 12 only for those parameters for which post-burn-in delta measurements are specified. All parameters shall be read and recorded at step 14.

Note 14: The PDA shall apply to all subgroup 1 parameters at 25°C and all delta parameters.

Note 15: Only one view is required for flat packages and leadless chip carriers with leads on all four sides.

Note 16: May be performed at any time prior to step 10.

## Table 4. Group A Electrical Tests

| Subgroup (Notes 1,2) | LTPD |
|---|---|
| **Subgroup 1**<br>Static Tests at 25°C | 2 |
| **Subgroup 2**<br>Static Tests at Maximum Rated Operating Temperature | 3 |
| **Subgroup 3**<br>Static Tests at Minimum Rated Operating Temperature | 5 |
| **Subgroup 4**<br>Dynamic Tests at 25°C | 2 |
| **Subgroup 5**<br>Dynamic Tests at Maximum Rated Operating Temperature | 3 |
| **Subgroup 6**<br>Dynamic Tests at Minimum Rated Operating Temperature | 5 |
| **Subgroup 7**<br>Functional Tests at 25°C | 2 |
| **Subgroup 8**<br>Functional Tests at Maximum and Minimum Rated Operating Temperatures | 5 |
| **Subgroup 9**<br>Switching Tests at 25°C | 2 |
| **Subgroup 10**<br>Switching Tests at Maximum Rated Operating Temperature | 3 |
| **Subgroup 11**<br>Switching Tests at Minimum Rated Operating Temperature | 5 |

Note 1: The specific parameters to be included for tests in each subgroup shall be as specified in the applicable procurement document. Where no parameters have been identified in a particular subgroup or test within a subgroup, no Group A testing is required for that subgroup or test.

Note 2: A single sample may be used for all subgroup testing. Where required size exceeds the lot size, 100% inspection shall be allowed.

Note 3: Group A testing by subgroup or within subgroups may be performed in any sequence, unless otherwise specified.

### Table 5. Group B (Class B)

| Test (Note 1) | Method | Condition | LTPD |
|---|---|---|---|
| **Subgroup 1** | | | |
| Physical Dimensions (Note 2) | 2016 | | 2 Devices (No Failures) |
| **Subgroup 2** | | | |
| Resistance to Solvents | 2015 | | 4 Devices (No Failures) |
| **Subgroup 3** | | | |
| Solderability (Note 3) | 2003 or 2022 | Soldering Temperature of 245 ± 5°C | 10 |
| **Subgroup 4** | | | |
| Internal Visual and Mechanical (Note 4) | 2014 | Failure Criteria from Design and Construction Requirements of Applicable Procurement Document | 1 Device (No Failures) |
| **Subgroup 5** | | | |
| Bond Strength (Note 5) | 2011 | | 15 |
| 1) Thermocompression | | 1) Condition C or D | |
| 2) Ultrasonic or Wedge | | 2) Condition C or D | |
| 3) Flip-Chip | | 3) Condition F | |
| 4) Beam Lead | | 4) Condition H | |
| **Subgroup 6** | | | |
| Internal Water-Vapor Content (Note 6) | 1018 | 1,000 ppm Maximum Water Content at 100°C | 3 Devices (0 Failures) (Note 7) or 5 Devices (1 Failure) |
| **Subgroup 7** | | | |
| Seal (Note 8)<br>1) Fine<br>2) Gross | 1014 | As Applicable | 5 |
| **Subgroup 8 (Note 9)** | | | |
| Electrical Parameters | | Group A, Subgroup 1 | |
| Electrostatic Discharge Sensitivity | 2015 | | 15 (0) |
| Electrical Parameters | | Group A, Subgroup 1 | |

Note 1: Electrical reject devices from the same inspection lot may be used for all subgroups when end-point measurements are not required, except for devices submitted to subgroup 7.

Note 2: Not required for qualification or quality conformance inspections where Group D inspection is being performed on samples from the same inspection lot.

Note 3: All devices submitted for solderability test shall be in the lead finish that will be on the shipped product and which has been through the temperature/time exposure of burn-in except for devices which have been hot-solder dipped or have undergone tin fusing after burn-in. The LTPD for solderability test applies to the number of leads inspected except in no case shall less than 3 devices be used to provide the number of leads required.

Note 4: Test samples for internal visual and mechanical shall be selected at any point following the seal operation.

Note 5: Test samples for bond strength may, at the manufacturer's option, unless otherwise specified, be randomly selected prior to or following internal visual (precap) inspection provided all other specification requirements are satisfied. Unless otherwise specified, the LTPD sample size for condition C or D is the number of bond pulls selected from a minimum number of 10 devices, and for conditions F or H is the number of dice (not bonds) (see Method 2011).

Note 6: This test is required only if the package contains a desiccant.

Note 7: Test 3 devices, if 1 fails, test 2 additional devices with no failure.

Note 8: This test is not required if either the 100% screen or sample test is performed between steps 14 and 18 and 100% screening of Table 3 of this section.

Note 9: Unless otherwise specified, test shall be performed for initial qualification and product redesign as a minimum.

## Table 6. Group B (Class S)

| Test (Note 1) | Method | Condition | Quantity/(Accept No.) or LTPD |
|---|---|---|---|
| **Subgroup 1** | | | |
| a) Physical Dimensions (Note 2) | 2016 | | 2 (0) |
| b) Internal Water-Vapor (Notes 2, 3) | 1018 | 5,000 ppm Maximum Water Content at 100°C | 3 (0) or 5 (1) (Note 4) |
| **Subgroup 2 (Note 5)** | | | |
| a) Resistance to Solvents | 2015 | | 4 (0) |
| b) Internal Visual and Mechanical | 2013 & 2014 | Failure Criteria from Design and Construction Requirements of Applicable Procurement Document | 2 (0) |
| c) Bond Strength (Note 6) | 2011 | | LTPD = 10 |
| 1) Thermocompression | | 1) Condition C or D | |
| 2) Ultrasonic | | 2) Condition C or D | |
| 3) Flip-Chip | | 3) Condition F | |
| 4) Beam Lead | | 4) Condition H | |
| d) Die Shear Test | 2019 | Per Method 2019 for the Applicable Die Size | 3 (0) |
| **Subgroup 3** | | | |
| Solderability (Note 7) | 2003 or 2022 | Soldering Temperature or 245 ± 5°C | LTPD = 15 |
| **Subgroup 4** | | | |
| Lead Integrity (Note 5) | 2004 | Condition $B_2$, Lead Fatigue | 2 (0) |
| Seal | 1014 | As Applicable | |
| 1) Fine | | | |
| 2) Gross | | | |
| Lid Torque (Note 3) | | As Applicable | |
| **Subgroup 5 (Notes 8, 9)** | | | |
| a) Electrical Parameters (Note 11) | | Group A, Subgroups 1, 2, 3: Read and Record<br>Group A, Subgroups 4–11: Attributes | LTPD = 5 |
| b) Steady State Life | 1005 | Condition C, D or E: 1000 hours | |
| c) Electrical Parameters | | Groups A, Subgroups 1, 2, 3: Read and Record<br>Group A, Subgroup 4–11: Attributes | |
| **Subgroup 6 (Note 5)** | | | |
| a) Electrical Parameters (Note 11) | | Group A, Subgroups 1, 2, 3: Read and Record | LTPD = 15 |
| b) Temperature Cycling | 1010 | Condition C, 100 Cycles/min. | |
| c) Constant Acceleration | 2001 | Test Condition E: $Y_1$ Orientation Only | |
| d) Seal | 1014 | | |
| 1) Fine | | | |
| 2) Gross | | | |
| e) Electrical Parameters | | Group A, Subgroups 1, 2, 3: Read and Record | |
| **Subgroup 7 (Note 12)** | | | |
| a) Electrical Parameters | | Group A, Subgroup 1 | 15 (0) |
| b) Electrostatic Discharge Sensitivity | 3015 | | |
| c) Electrical Parameters | | Group A, Subgroup 1 | |

Note 1: Electrical reject devices from the same inspection may be used for all subgroups where electrical end-point measurements are not required.

Note 2: Not required for qualification or quality conformance inspections where Group D inspection is being performed on samples from the same inspection lot.

Note 3: This test is required only if it is a glass-frit sealed package.

Note 4: Test 3 devices; if 1 fails, test 2 additional devices with no failures.

Note 5: All samples for subgroup B2 must have been through the complete sequence of subgroup B6 tests.

Note 6: Unless otherwise specified, the LTPD sample size for conditions C and D is the number of bond pulls selected from a minimum of 4 devices and for conditions F and H is the number of dice (not bonds).

Note 7: All devices must be in the same lead finish that will be on the shipped product and shall have been through the temperature/time exposure of burn-in except for devices that have been hot-solder dipped or undergone tin fusing after burn-in. The LTPD applies to the number of leads inspected, except in no case shall less than 3 devices be used to provide the number of leads required.

Note 8: The alternate removal-of-bias provisions of Method 1005 shall not apply for test temperatures above 125°C.

Note 9: The same temperature must be employed for operating life that was used for the 100% burn-in.

Note 10: For leadless chip carriers, condition D will apply.

Note 11: Read and record data from Group A of quality conformance is acceptable.

Note 12: Unless otherwise specified, test shall be performed for initial qualification and product redesign as a minimum.

### Table 7. Group C (Die-Related Tests for Class B and C Only)

| Test | Method | Condition | LTPD |
|---|---|---|---|
| **Subgroup 1** | | | |
| Steady State Life Test | 1005 | Test Condition to be Specified (1,000 hours at 125°C) | 5 |
| End-point Electrical Parameters | | As Specified in the Applicable Device Specification | |
| **Subgroup 2** | | | |
| Temperature Cycling | 1010 | Condition C | 15 |
| Constant Acceleration | 2001 | Condition E min, $Y_1$ Orientation Only (Note 1) | |
| Seal | 1014 | As Applicable | |
| a) Fine | | | |
| b) Gross | | | |
| Visual Examination | | Per Visual Criteria of Method 1010 or 1011 as | |
| End-point Electrical Parameters | | Specified in the Applicable Device Specification | |

Note 1: See paragraph 3 of Method 5005 for the procedure for large cavity package.

## Table 8. Group D (Package-Related Tests for Classes)

| Test | Method | Condition | LTPD |
|---|---|---|---|
| **Subgroup 1 (Note 1)** | | | |
| a) Physical Dimensions | 2016 | | 15 |
| **Subgroup 2 (Notes 1, 4)** | | | |
| Lead Integrity | 2004 | Test Condition B2 (Lead Fatigue) (Note 10) | 15 |
| Seal | 1014 | As Applicable | |
| a) Fine | | | |
| b) Gross | | | |
| **Subgroup 3 (Note 3)** | | | |
| Thermal Shock | 1011 | Test Condition B Minimum, 15 Cycles Minimum | 15 |
| Temperature Cycling | 1010 | Test Condition C, 100 Cycles Minimum | |
| Moisture Resistance (Note 4) | 1004 | | |
| Seal | 1014 | As Applicable | |
| a) Fine | | | |
| b) Gross | | | |
| Visual Examination | | Per Visual Criteria of Method 1004 or 1010 | |
| End-point Electrical Parameters (Note 4) | | As Specified in the Applicable Device Specification | |
| **Subgroup 4 (Note 3)** | | | |
| Mechanical Shock | 2002 | Test Condition B Minimum | 15 |
| Vibration Variable Frequency | 2007 | Test Condition A Minimum | |
| Constant Acceleration | 2001 | Test Condition E Minimum<br>$Y_1$ Orientation Only (Note 6) | |
| Seal | 1014 | As Applicable | |
| a) Fine | | | |
| b) Gross | | | |
| Visual Examination | | Per Visual Criteria of Method 1010 or 1011 | |
| End-point Electrical Parameters | | As Specified in the Applicable Device Specification | |
| **Subgroup 5 (Note 1)** | | | |
| Salt Atmosphere | 1009 | Test Condition A Minimum | 15 |
| Seal | 1014 | As Applicable | |
| a) Fine | | | |
| b) Gross | | | |
| Visual Examination | | Per Visual Criteria of Method 1009 | |
| **Subgroup 6 (Note 1)** | | | |
| Internal Water-Vapor Content | 1018 | 5,000 ppm Maximum Water Content at 100°C | 3 Devices (0 Failures) or 5 Devices (1 Failure) (Note 5) |
| **Subgroup 7 (Note 1)** | | | |
| Adhesion of Lead Finish (Notes 7, 8) | 2025 | | 15 |
| **Subgroup 8 (Note 1)** | | | |
| Lid Torque (Note 2) | 2024 | | 5 (0) |

Note 1: Electrical reject devices from that same inspection lot may be used for samples.

Note 2: Lid torque test shall apply only to packages which use a glass-frit seal to lead frame, lead or package body (i.e., wherever frit seal establishes hermeticity or package integrity).

Note 3: Devices used in subgroup 3, "Thermal and Moisture Resistance" may be used in Subgroup 4 "Mechanical".

Note 4: At the manufacturer's option, end-point electrical parameters may be performed after moisture resistance and prior to seal test.

Note 5: Test 3 devices; if 1 fails, test 2 additional devices with no failures.

Note 6: See paragraph 3 of Method 5005 for the procedure for large cavity packages.

Note 7: Does not apply to leadless chip carriers.

Note 8: The LTPD applies to the number of leads to be tested.

Note 9: The lead bend stress initial conditioning is not required for leadless chip carriers.

Note 10: For leadless chip carriers only, condition D shall apply.

## Table 9. Group E (Radiation Hardness Assurance Tests)

| Test (Note 1) | Method | Condition | Quantity (Accept Number = 0)<br>Class S | <br>Class B |
|---|---|---|---|---|
| **Subgroup 1 (Note 3)** | | | | |
| Neutron Irradiation | 1017 | 25°C | | |
| a) Qualification | | | 11 per Wafer Lot | 5 from each of 3 Wafer Lots |
| b) Quality Conformance | | | 11 per Wafer Lot | 11 per Wafer Lot |
| End-point Electrical Parameters | | Per Applicable Detail Specification | | |
| **Subgroup 2** | | | | |
| Steady-state Total Dose Irradiation | 1019 | 25°C, Maximum Supply Voltage | | |
| a) Qualification | | | (Note 2) | 5 from each of 3 Wafer Lots |
| b) Quality Conformance | | | (Note 2) | 11 per Wafer Lot |
| End-point Electrical Parameters | | Per Applicable Detail Specification | | |

Note 1: Parts used for one subgroup test may not be used for the other subgroup but may be used for higher levels in the same subgroup. Total exposure shall not be sonsidered cumulative unless testing is performed within the time limits of the test method.

Note 2: 4 per wafer for devices type S less than or equal to 4000 equivalent transistors per chip, 2 per wafer for larger dice. Samples will be selected at radius approximately equal to two-thirds of the wafer radius and spaced uniformly around this radius.

Note 3: Subgroup 1 is not required for MOS devices.

## Table 10. Wafer Lot Acceptance Tests

| Test | Conditions (Note 1) | Limits (Note 2) | Sampling Plan |
|---|---|---|---|
| 1. Wafer Thickness (not required when the finished wafer design thickness is greater than 10 mils) | MIL-STD-977, Method 1580. Measurement shall be performed after final lap or polish. All readings shall be recorded. | Maximum deviation of ± 2 mil for approved design nominal 6 mil minimum. | Two wafers per lot. Reject lot if any measurement exceeds limits or revert to test of each wafer. |
| 2. Metallization thickness | MIL-STD-977 Method 5500. All readings shall be recorded. | a) Conductor: 8 kÅ minimum for single level metal and for the top level of multi-level metal: 6 kÅ minimum for lower levels, with a maximum deviation of ± 20% from the approved design nominal.<br>b) Barrier: Maximum deviation of ± 30% from the approved design nominal. | One wafer (or monitor) per lot. Reject lot if measurement exceeds limits or revert to test of each wafer. |
| 3. Thermal stability (applicable to: all linear; all MOS; all bipolar digital operating at 10V or more) | MIL-STD-977, Method 2500. Record $V_{FB}$ or $V_T$. (Note 3) | a) $\triangle V_{FB}$ or $\triangle V_T \leq 0.75V$ for bipolar digital devices operating at $\geq 10V$ and all bipolar linear devices not containing MOS transistors. The monitor shall have an oxide and shall be metallized with the lot.<br>b) $\triangle V_{FB}$ or $\triangle V_T \leq 1.0V$ for bipolar linear devices that operate above 5V and contain MOS transistors and digital devices that operate above 10V and contain MOS structures.<br>c) $\triangle V_{FB}$ or $\triangle V_T \leq 0.4V$ for MOS devices. | One wafer (or monitor) per lot. Reject lot if measurement exceeds limits or revert to test of each wafer.<br>Separate monitors may be used but must be oxidized and metallized with the lot.<br>A monitor consisting of a gate oxide metallized with the lot shall be used. |
| 4. SEM (Note 4) | MIL-STD-883, Method 2018. | MIL-STD-883, Method 2018. | MIL-STD-883, Method 2018. Lot acceptance basis. |
| 5. Glassivation Thickness | MIL-STD-977, Method 5500. All readings shall be recorded. | 6 kÅ minimum for $SiO_2$ and 2kÅ minimum $Si_3N_4$ with maximum deviation of ± 20% from approved design nominal. | One wafer (or monitor) per lot. Reject lot if any measurement exceeds limits or revert to test of each wafer. |
| 6. Gold backing thickness (when applicable) | MIL-STD-977, Method 5500. All readings shall be recorded. | Per approved design nominal thickness and tolerance. | One wafer (or monitor) per lot. Reject lot if any measurement exceeds limits or revert to test of each wafer. |

**Note 1:** Approved equivalent test methods may be used in lieu of the referenced MIL-STD-977 methods.

**Note 2:** Approved design nominal values or tolerances shall be submitted for line certification per DESC-EQM-42.

**Note 3:** All readings shall be normalized to oxide thickness of 1000Å.

**Note 4:** When wafer lots fail to pass the SEM requirements of Method 2018, compliance with the current density requirement shall not be used to waiver the SEM requirement.

# Packaging

For additional Packaging information, see page 373.

# Surface Mount Devices—Product Availability

## Analog

All of the major analog product families are available now in surface mount packages. Most of the products are produced in the SOIC package, including op amps, regulators, data conversion, consumer, and automotive ICs. More highly specialized telecom products come packaged in the PLCC.

### Amplifiers and Comparators

| Part Number | Package |
|---|---|
| LF347WM | SO-14W |
| LF351M | SO-8 |
| LF355M | SO-8 |
| LF356M | SO-8 |
| LF357M | SO-8 |
| LF441CM | SO-8 |
| LF444CWM | SO-14W |
| LF451CM | SO-8 |
| LM308M | SO-8 |
| LM308AM | SO-8 |
| LM310M | SO-8 |
| LM311M | SO-8 |
| LM318M | SO-8 |
| LM324M | SO-14 |
| LM339M | SO-14 |
| LM346M | SO-16 |
| LM348M | SO-14 |
| LM358M | SO-8 |
| LM359M | SO-14 |
| LM392M | SO-8 |
| LM393M | SO-8 |
| LM741CM | SO-8 |
| LM1458M | SO-8 |
| LM2901M | SO-14 |
| LM2902M | SO-14 |
| LM2903M | SO-8 |
| LM2904M | SO-8 |
| LM2924M | SO-8 |
| LM3403M | SO-8 |
| LM4250M | SO-8 |
| LP324M | SO-14 |
| LP339M | SO-14 |
| LP365WM | SO-16W |
| LMC669CCWM | SO-20W |

### Regulators and References

| Part Number | Package |
|---|---|
| LM317LM | SO-8 |
| LM334M | SO-8 |
| LM336M-2.5 | SO-8 |
| LM336BM-2.5 | SO-8 |
| LM336M-5.0 | SO-8 |
| LM336BM-5.0 | SO-8 |
| LM385M | SO-8 |
| LM385M-1.2 | SO-8 |
| LM385BM-1.2 | SO-8 |
| LM385M-2.5 | SO-8 |
| LM385BM-2.5 | SO-8 |
| LM723CM | SO-14 |
| LM3524M | SO-16 |
| LM78L05ACM | SO-8 |
| LM78L12ACM | SO-8 |
| LM78L15ACM | SO-8 |
| LM79L05ACM | SO-8 |
| LM79L12ACM | SO-8 |
| LM79L15ACM | SO-8 |
| LP2951ACM | SO-8 |
| LP2951CM | SO-8 |

# Analog

## Data Acquisition Circuits

| Part Number | Package |
|---|---|
| ADC0802LCV | PCC-20 |
| ADC0802LCWM | SO-20 |
| ADC0804LCV | PCC-20 |
| ADC0804LCWM | SO-20 |
| ADC0808CCV | PCC-28 |
| ADC0809CCV | PCC-28 |
| ADC0811BCV | PCC-20 |
| ADC0811CCV | PCC-20 |
| ADC0820BCV | PCC-20 |
| ADC0820CCV | PCC-20 |
| ADC0838BCV | PCC-20 |
| ADC0838CCV | PCC-20 |
| ADC0841BCV | PCC-20 |
| ADC0841CCV | PCC-20 |
| ADC0848BCV | PCC-28 |
| ADC0848CCV | PCC-28 |
| DAC0800LCM | SO-16 |
| DAC0801LCM | SO-16 |
| DAC0802LCM | SO-16 |
| DAC0806LCM | SO-16 |
| DAC0807LCM | SO-16 |
| DAC0808LCM | SO-16 |
| DAC0830LCWM | SO-20 |
| DAC0830LCV | PCC-20 |
| DAC0832LCWM | SO-20 |
| DAC0832LCV | PCC-20 |

## Hybrids

| Part Number | Package |
|---|---|
| LH0002E | LCC-20 |

## Commercial and Automotive

| Part Number | Package |
|---|---|
| LM386M-1 | SO-8 |
| LM592M | SO-14 |
| LM832M | SO-14 |
| LM833M | SO-8 |
| LM837M | SO-14 |
| LM1131CM | SO-20 |
| LM1863M | SO-20 |
| LM1870M | SO-20 |
| LM1894M | SO-14 |
| LM1964V | PCC-20 |
| LM3361AM | SO-16 |

## Telecom Circuits

| Part Number | Package |
|---|---|
| TP3051V | PCC-20 |
| TP3052V | PCC-20 |
| TP3056V | PCC-20 |
| TP3057V | PCC-20 |
| TP3064V | PCC-20 |
| TP3067V | PCC-20 |
| TP3155V | PCC-20 |
| TP5088WM | SO-16W |
| TP5089WM | SO-14W |
| TP5700WM | SO-16 |

## Industrial Functions

| Part Number | Package |
|---|---|
| AH5012CM | SO-16 |
| LF13201M | SO-16 |
| LF13202M | SO-16 |
| LF13331M | SO-16 |
| LF13332M | SO-16 |
| LF13333M | SO-16 |
| LF13508M | SO-16 |
| LF13509M | SO-16 |
| LM555CM | SO-8 |
| LM556CM | SO-14 |
| LM567CM | SO-8 |
| LM1496M | SO-14 |
| LM2917M | SO-14 |
| LM3046M | SO-14 |
| LM3086M | SO-14 |
| LM3146M | SO-14 |
| MF4CWM-50 | SO-14W |
| MF4CWM-100 | SO-14W |
| MF5CWM | SO-14W |
| MF6CWM-50 | SO-14W |
| MF6CWM-100 | SO-14W |
| MF10CCWM | SO-20W |

## Gate Array

National's SCX family of SCX6200 micro-CMOS gate arrays are offered in a wide variety of packages which allows the user many choices in terms of package type and lead count. Surface mount packages offered include leaded ceramic chip carriers (LDCC), leadless ceramic chip carriers (LCC), and plastic leaded chip carriers (PCC).

| Part Number | Package |
|---|---|
| SCX6206 | PCC-28<br>LCC-28<br>PCC-44<br>LCC-44<br>PCC-68<br>LCC-68 |
| SCX6212 | PCC-28<br>LCC-28<br>PCC-44<br>LCC-44<br>PCC-68<br>LCC-68 |
| SCX6218 | PCC-28<br>LCC-28<br>PCC-44<br>LCC-44<br>PCC-68<br>PCC-84<br>LCC-84 |

| Part Number | Package |
|---|---|
| SCX6225 | PCC-28<br>LCC-28<br>PCC-44<br>LCC-44<br>PCC-68<br>LCC-68<br>PCC-84<br>LCC-84<br>LDCC-124 |
| SCX6232 | PCC-44<br>LCC-44<br>PCC-68<br>LCC-68<br>PCC-84<br>LCC-84<br>LCC-124<br>LDCC-124 |
| SCX6244 | PCC-44<br>LCC-44<br>PCC-68<br>LCC-68<br>PCC-84<br>LCC-84<br>LDCC-124 |
| SCX6287 | PCC-68<br>PCC-84<br>LCC-84 |

## Interface

National's Advanced Peripherals family of products is available in a variety of package types. These LSI devices provide system solutions to complex functions including Hard and Floppy Disk Drive Control, 16k, 64k, 256k and 4 megabit DRAM Control, Ethernet/Thin Ethernet Network Interface, and Graphics Support.

These products make use of National's advanced PCC packaging technology to produce large pin count devices in the most efficient and reliable manner possible. Of note, National's Auto-Die Attach Process, in volume production for over 5 years, is the most advanced technique in the industry for bonding out high pin count PCC and LCC packages.

### BTL Transceivers

| Part Number | Package |
|---|---|
| DS3897V | PCC-20 |
| DS3893V | PCC-20 |

### Graphics

| Part Number | Package |
|---|---|
| DP8510V | PCC-44 |
| DP8511V | PCC-44 |
| DP8512 | PCC-44 |
| DP8513 | PCC-44 |
| DP8514 | PCC-20 |
| DP8530 | PCC-28 |
| DP8515 | PCC-44 |
| DP8516 | PCC-44 |
| DP8520 | PCC-68 |
| DP8521 | PCC-68 |
| DP8522 | PCC-68 |
| DP8530 | PCC-28 |

### Interface

| Part Number | Package |
|---|---|
| DS1488M | SO-14 |
| DS1489M | SO-14 |
| DS1489AM | SO-14 |
| DS14C88M | SO-14 |
| DS14C89M | SO-14 |
| DS26LS31CM | SO-16 |
| DS26LS32CM | SO-16 |
| DS26S10V | PCC-20 |
| DS3486M | SO-16 |
| DS3487M | SO-16 |
| DS3650M | SO-16 |
| DS3680M | SO-14 |
| DS3691M | SO-16 |
| DS75150M | SO-8 |
| DS75154M | SO-16 |
| DS75492M | SO-14 |
| DS75113M | SO-16 |
| DS8837M | SO-16 |
| DS8838M | SO-16 |
| DP8304BWM | SO-24 |
| DP8340V | PCC-28 |
| DP8341V | PCC-28 |
| DP8344V | PCC-84 |
| DS8921AM | SO-8 |
| DS8921M | SO-8 |
| DS8922AM | SO-16 |
| DS8922M | SO-16 |
| DS8923AM | SO-16 |
| DS8923M | SO-16 |

### LAN

| Part Number | Package |
|---|---|
| DP8390 | PCC-68 |
| DP8391 | PCC-28 |

### Mass Storage

| Part Number | Package |
|---|---|
| DP8466AV | PCC-68 |
| DP8474V | PCC-44 |
| DP8451V | PCC-20 |
| DP8455V | PCC-20 |
| DP8461V | PCC-28 |
| DP8462V | PCC-28 |
| DP8463BV | PCC-28 |
| DP8464BV | PCC-28 |
| DP8465V | PCC-28 |
| DP8470V | PCC-44 |
| DP8475BV | PCC-44 |

### Memory Support

| Part Number | Package |
|---|---|
| DP8400V-2 | PCC-68 |
| DP8402AV | PCC-68 |
| DP8409AV-2 | PCC-68 |
| DP8417V | PCC-68 |
| DP8418V | PCC-68 |
| DP8419V | PCC-68 |
| DP8420V | PCC-68 |
| DP8421V | PCC-68 |
| DP8422V | PCC-68 |
| DP8428V | PCC-68 |
| DP8429V | PCC-68 |
| DP84240V | PCC-20 |
| DP84244V | PCC-20 |

### Real Time Clocks

| Part Number | Package |
|---|---|
| DP8570V | PCC-28 |
| MM58167AV | PCC-28 |
| MM58274V | PCC-20 |

## Logic

National Semiconductor's Advanced Low-Power Schottky (ALS) and Advanced Schottky (AS) devices are among the latest advancements in TTL integrated circuit technology. The performance advantages offered by these families are further enhanced by surface mount technology. Many AS/ALS devices are available in the Small Outline package.

Low power dissipation, high speed, and high reliability can describe the benefits available from Small Outline packaging of National's 74HC Logic Family. Utilization of these products in the surface mounted packages will result in improvements in packing density.

While HC and AS/ALS circuits are available for most new designs, National is continuing its effort to provide the widest selection of surface mount components. Traditional Schottky (S) and Low Power Schottky (LS) devices are also available in the SO package.

### ALS

| Part Number | Package |
|---|---|
| DM74ALS00AM | SO-14 |
| DM74ALS01M | SO-14 |
| DM74ALS02M | SO-14 |
| DM74ALS03BM | SO-14 |
| DM74ALS04AM | SO-14 |
| DM74ALS05AM | SO-14 |
| DM74ALS08M | SO-14 |
| DM74ALS09M | SO-14 |
| DM74ALS10AM | SO-14 |
| DM74ALS11AM | SO-14 |
| DM74ALS12AM | SO-14 |
| DM74ALS13M | SO-14 |
| DM74ALS14M | SO-14 |
| DM74ALS15M | SO-14 |
| DM74ALS20AM | SO-14 |
| DM74ALS21M | SO-14 |
| DM74ALS22BM | SO-14 |
| DM74ALS27M | SO-14 |
| DM74ALS28AM | SO-14 |
| DM74ALS30AM | SO-14 |
| DM74ALS32M | SO-14 |
| DM74ALS33AM | SO-14 |
| DM74ALS37AM | SO-14 |
| DM74ALS38AM | SO-14 |
| DM74ALS40AM | SO-14 |
| DM74ALS74AM | SO-14 |
| DM74ALS109AM | SO-16 |
| DM74ALS131M | SO-16 |
| DM74ALS132M | SO-14 |
| DM74ALS133M | SO-16 |
| DM74ALS137M | SO-16 |
| DM74ALS138M | SO-16 |
| DM74ALS151M | SO-16 |
| DM74ALS153M | SO-16 |
| DM74ALS160BM | SO-16 |
| DM74ALS161BM | SO-16 |
| DM74ALS162BM | SO-16 |
| DM74ALS163BM | SO-16 |
| DM74ALS168BM | SO-16 |

| Part Number | Package |
|---|---|
| DM74ALS169BM | SO-16 |
| DM74ALS174M | SO-16 |
| DM74ALS175M | SO-16 |
| DM74ALS240AWM | SO-20 |
| DM74ALS241AWM | SO-20 |
| DM74ALS242AM | SO-14 |
| DM74ALS243AM | SO-14 |
| DM74ALS244AWM | SO-20 |
| DM74ALS245AWM | SO-20 |
| DM74ALS251M | SO-16 |
| DM74ALS253M | SO-16 |
| DM74ALS2541WM | SO-16 |
| DM74ALS257AM | SO-16 |
| DM74ALS258AM | SO-16 |
| DM74ALS273WM | SO-20 |
| DM74ALS352M | SO-16 |
| DM74ALS353M | SO-16 |
| DM74ALS373WM | SO-20 |
| DM74ALS374WM | SO-20 |
| DM74ALS465AWM | SO-20 |
| DM74ALS466AWM | SO-20 |
| DM74ALS467AWM | SO-20 |
| DM74ALS468AWM | SO-20 |
| DM74ALS518WM | SO-20 |
| DM74ALS519WM | SO-20 |
| DM74ALS520WM | SO-20 |
| DM74ALS521WM | SO-20 |
| DM74ALS522WM | SO-20 |
| DM74ALS533WM | SO-20 |
| DM74ALS534WM | SO-20 |
| DM74ALS540WM | SO-20 |
| DM74ALS541WM | SO-20 |
| DM74ALS563WM | SO-20 |
| DM74ALS564WM | SO-20 |
| DM74ALS573AWM | SO-20 |
| DM74ALS574AWM | SO-20 |
| DM74ALS576AWM | SO-20 |
| DM74ALS580AWM | SO-20 |

# Logic

## ALS

| Part Number | Package |
|---|---|
| DM74ALS632AV/DP8402AV | PCC-68 |
| DM74ALS645AWM | SO-20 |
| DM74ALS689WM | SO-20 |
| DM74ALS804WM | SO-20 |
| DM74ALS805WM | SO-20 |
| DM74ALS808WM | SO-20 |
| DM74ALS832WM | SO-20 |
| DM74ALS1000AM | SO-14 |
| DM74ALS1002AM | SO-14 |
| DM74ALS1003AM | SO-14 |
| DM74ALS1004M | SO-14 |
| DM74ALS1005M | SO-14 |
| DM74ALS1008AM | SO-14 |
| DM74ALS1010AM | SO-14 |
| DM74ALS1011AM | SO-14 |
| DM74ALS1020AM | SO-14 |
| DM74ALS1032AM | SO-14 |
| DM74ALS1034WM | SO-20 |
| DM74ALS1035M | SO-14 |
| DM74ALS1240AWM | SO-20 |
| DM74ALS1241AWM | SO-20 |
| DM74ALS1242AM | SO-14 |
| DM74ALS1243AM | SO-14 |
| DM74ALS1244AWM | SO-20 |

## LS

| Part Number | Package |
|---|---|
| DM74LS00M | SO-14 |
| DM74LS02M | SO-14 |
| DM74LS03M | SO-14 |
| DM74LS04M | SO-14 |
| DM74LS05M | SO-14 |
| DM74LS08M | SO-14 |
| DM74LS09M | SO-14 |
| DM74LS10M | SO-14 |
| DM74LS11M | SO-14 |
| DM74LS12M | SO-14 |
| DM74LS14M | SO-14 |
| DM74LS20M | SO-14 |
| DM74LS21M | SO-14 |
| DM74LS26M | SO-14 |
| DM74LS27M | SO-14 |
| DM74LS30M | SO-14 |
| DM74LS32M | SO-14 |
| DM74LS37M | SO-14 |
| DM74LS38M | SO-14 |
| DM74LS42M | SO-14 |
| DM74LS51M | SO-14 |
| DM74LS73AM | SO-14 |
| DM74LS74AM | SO-14 |
| DM74LS75M | SO-14 |
| DM74LS77M | SO-14 |
| DM74LS83AWM | SO-16 |
| DM74LS85M | SO-16 |
| DM74LS86M | SO-14 |
| DM74LS90M | SO-14 |
| DM74LS93M | SO-14 |
| DM74LS107AM | SO-14 |
| DM74LS109AM | SO-16 |
| DM74LS112AM | SO-16 |
| DM74LS122M | SO-14 |
| DM74LS123M | SO-16 |
| DM74LS125AM | SO-14 |
| DM74LS126AM | SO-14 |
| DM74LS132M | SO-14 |
| DM74LS138M | SO-16 |
| DM74LS139M | SO-16 |
| DM74LS151M | SO-16 |
| DM74LS153M | SO-16 |
| DM74LS155M | SO-16 |
| DM74LS156M | SO-16 |
| DM74LS157M | SO-16 |
| DM74LS158M | SO-16 |
| DM74LS161AM | SO-16 |
| DM74LS163AM | SO-16 |
| DM74LS164M | SO-14 |
| DM74LS165M | SO-16 |
| DM74LS166WM | SO-16W |
| DM74LS169AM | SO-16 |
| DM74LS173AM | SO-16 |
| DM74LS174AM | SO-16 |
| DM74LS175M | SO-16 |
| DM74LS190M | SO-16 |
| DM74LS191M | SO-16 |
| DM74LS193M | SO-16 |
| DM74LS194AM | SO-16 |
| DM74LS195AM | SO-16 |
| DM74LS221M | SO-16 |
| DM74LS240WM | SO-20 |
| DM74LS241WM | SO-20 |
| DM74LS243WM | SO-14W |
| DM74LS244WM | SO-20 |
| DM74LS245WM | SO-20 |
| DM74LS251M | SO-16 |
| DM74LS253M | SO-16 |
| DM74LS257BM | SO-16 |
| DM74LS258BM | SO-16 |
| DM74LS259WM | SO-16W |
| DM74LS279M | SO-16 |
| DM74LS283M | SO-16 |
| DM74LS290M | SO-14 |
| DM74LS293M | SO-14 |
| DM74LS352M | SO-16 |
| DM74LS365AM | SO-16 |
| DM74LS366AM | SO-16 |
| DM74LS367AM | SO-16 |
| DM74LS368AM | SO-16 |
| DM74LS373WM | SO-20 |
| DM74LS374WM | SO-20 |
| DM74LS390M | SO-16 |
| DM74LS645WM | SO-20 |
| DM74LS670M | SO-16 |
| DM81LS95AWM | SO-20 |
| DM81LS96AWM | SO-20 |
| DM81LS97AWM | SO-20 |
| DM81LS98AWM | SO-20 |

# Logic

## Schottky

| Part Number | Package |
|---|---|
| DM74S00M | SO-14 |
| DM74S04M | SO-14 |
| DM74S74M | SO-14 |
| DM74S86M | SO-14 |
| DM74S151M | SO-16 |
| DM74S240WM | SO-20 |
| DM74S244WM | SO-20 |
| DM74S280M | SO-14 |
| DM74S373WM | SO-20 |
| DM74S374WM | SO-20 |

## TTL

| Part Number | Package |
|---|---|
| DM7400M | SO-14 |
| DM7404M | SO-14 |
| DM7406M | SO-14 |
| DM7407M | SO-14 |
| DM7438M | SO-14 |
| DM7474M | SO-14 |

## AS

| Part Number | Package |
|---|---|
| DM74AS00M | SO-14 |
| DM74AS02M | SO-14 |
| DM74AS04M | SO-14 |
| DM74AS08M | SO-14 |
| DM74AS32M | SO-14 |
| DM74AS74M | SO-14 |
| DM74AS244M | SO-20 |
| DM74AS280M | SO-14 |
| DM74AS373M | SO-20 |
| DM74AS374M | SO-20 |
| DM74AS574M | SO-20 |
| DM74AS804BM | SO-20 |
| DM74AS808BM | SO-20 |
| DM74AS832BM | SO-20 |

## CD4000

| Part Number | Package |
|---|---|
| CD4001BCM | SO-14 |
| CD4002BCM | SO-14 |
| CD4007BCM | SO-14 |
| CD4010CM | SO-16 |
| CD4011BCM | SO-14 |
| CD4013BCM | SO-14 |
| CD4015CM | SO-16 |
| CD4016BCM | SO-14 |
| CD4017BCM | SO-16 |
| CD4019BCM | SO-16 |
| CD4020BCM | SO-16 |
| CD4021BCM | SO-16 |
| CD4023BCM | SO-14 |
| CD4024BCM | SO-14 |
| CD4025BCM | SO-14 |
| CD4040BCM | SO-16 |
| CD4041CM | SO-14 |
| CD4042BCM | SO-16 |
| CD4046BCM | SO-16 |
| CD4047BCM | SO-14 |
| CD4049CM | SO-16 |
| CD4050BCM | SO-16 |
| CD4051BCM | SO-16 |
| CD4052BCM | SO-16 |
| CD4053BCM | SO-16 |
| CD4060BCM | SO-16 |
| CD4066BCM | SO-14 |
| CD4069UBCM | SO-14 |
| CD4070BCM | SO-14 |
| CD4071BCM | SO-14 |
| CD4081BCM | SO-14 |
| CD4093BCM | SO-14 |
| CD4528BCM | SO-16 |
| CD40174BCM | SO-16 |
| CD40193BCM | SO-16 |

# Logic

## HC

| Part Number | Package |
|---|---|
| MM74HC00M | SO-14 |
| MM74HC02M | SO-14 |
| MM74HC03M | SO-14 |
| MM74HCU04M | SO-14 |
| MM74HC04M | SO-14 |
| MM74HC08M | SO-14 |
| MM74HC10M | SO-14 |
| MM74HC11M | SO-14 |
| MM74HC14M | SO-14 |
| MM74HC20M | SO-14 |
| MM74HC27M | SO-14 |
| MM74HC30M | SO-14 |
| MM74HC32M | SO-14 |
| MM74HC42M | SO-16 |
| MM74HC51M | SO-14 |
| MM74HC58M | SO-14 |
| MM74HC73M | SO-14 |
| MM74HC74AM | SO-14 |
| MM74HC75M | SO-16 |
| MM74HC76M | SO-16 |
| MM74HC86M | SO-14 |
| MM74HC109AM | SO-16 |
| MM74HC123AM | SO-16 |
| MM74HC125M | SO-14 |
| MM74HC126M | SO-14 |
| MM74HC132M | SO-14 |
| MM74HC133M | SO-16 |
| MM74HC137M | SO-16 |
| MM74HC138M | SO-16 |
| MM74HC139M | SO-16 |
| MM74HC147M | SO-16 |
| MM74HC149WM | SO-20 |
| MM74HC151M | SO-16 |
| MM74HC153M | SO-16 |
| MM74HC154WM | SO-24 |
| MM74HC157M | SO-16 |
| MM74HC158M | SO-16 |
| MM74HC160M | SO-16 |
| MM74HC161M | SO-16 |
| MM74HC162M | SO-16 |

| Part Number | Package |
|---|---|
| MM74HC163M | SO-16 |
| MM74HC164M | SO-14 |
| MM74HC165M | SO-16 |
| MM74HC173M | SO-16 |
| MM74HC174M | SO-16 |
| MM74HC175M | SO-16 |
| MM74HC181WM | SO-24 |
| MM74HC182M | SO-16 |
| MM74HC221AM | SO-16 |
| MM74HC237M | SO-16 |
| MM74HC240WM | SO-20 |
| MM74HC241WM | SO-20 |
| MM74HC242M | SO-14 |
| MM74HC243M | SO-14 |
| MM74HC244WM | SO-20 |
| MM74HC245AWM | SO-20 |
| MM74HC251M | SO-16 |
| MM74HC253M | SO-16 |
| MM74HC257M | SO-16 |
| MM74HC259M | SO-16 |
| MM74HC266AM | SO-14 |
| MM74HC273WM | SO-20 |
| MM74HC280M | SO-14 |
| MM74HC283M | SO-16 |
| MM74HC298M | SO-16 |
| MM74HC299WM | SO-20 |
| MM74HC354WM | SO-20 |
| MM74HC356WM | SO-20 |
| MM74HC365WM | SO-16 |
| MM74HC366WM | SO-16 |
| MM74HC367WM | SO-16 |
| MM74HC368WM | SO-16 |
| MM74HC373WM | SO-20 |

| Part Number | Package |
|---|---|
| MM74HC374WM | SO-20 |
| MM74HC393M | SO-14 |
| MM74HC423AM | SO-16 |
| MM74HC521WM | SO-20 |
| MM74HC533WM | SO-20 |
| MM74HC534WM | SO-20 |
| MM74HC540WM | SO-20 |
| MM74HC541WM | SO-20 |
| MM74HC563WM | SO-20 |
| MM74HC564WM | SO-20 |
| MM74HC573WM | SO-20 |
| MM74HC574WM | SO-20 |
| MM74HC589M | SO-16 |
| MM74HC595M | SO-16 |
| MM74HC597M | SO-16 |
| MM74HC640WM | SO-20 |
| MM74HC643WM | SO-20 |
| MM74HC646M | SO-24 |
| MM74HC648M | SO-24 |
| MM74HC688WM | SO-20 |
| MM74HC942WM | SO-20 |
| MM74HC943WM | SO-20 |
| MM74HC4002M | SO-14 |
| MM74HC4016WM | SO-14 |
| MM74HC4017M | SO-14 |
| MM74HC4020M | SO-16 |
| MM74HC4040M | SO-16 |
| MM74HC4046M | SO-16 |
| MM74HC4049M | SO-16 |
| MM74HC4050M | SO-16 |
| MM74HC4051WM | SO-16 |
| MM74HC4052WM | SO-16 |
| MM74HC4053WM | SO-16 |
| MM74HC4060M | SO-16 |
| MM74HC4066WM | SO-14 |
| MM74HC4075M | SO-14 |
| MM74HC4078M | SO-14 |
| MM74HC4316WM | SO-16 |
| MM74HC4511M | SO-16 |
| MM74HC4514WM | SO-24 |
| MM74HC4538M | SO-16 |
| MM74HC4543M | SO-16 |
| MM74HC7266M | SO-14 |

# Logic

## HCT

| Part Number | Package |
|---|---|
| MM74HCT00M | SO-14 |
| MM74HCT04M | SO-14 |
| MM74HCT05M | SO-14 |
| MM74HCT34M | SO-14 |
| MM74HCT74M | SO-14 |
| MM74HCT138M | SO-16 |
| MM74HCT149WM | SO-20 |
| MM74HCT151M | SO-16 |
| MM74HCT164M | SO-14 |
| MM74HCT240WM | SO-20 |
| MM74HCT241WM | SO-20 |
| MM74HCT244WM | SO-20 |
| MM74HCT245WM | SO-20 |
| MM74HCT251M | SO-16 |
| MM74HCT273WM | SO-20 |
| MM74HCT373WM | SO-20 |
| MM74HCT374WM | SO-20 |
| MM74HCT521WM | SO-20 |
| MM74HCT540WM | SO-20 |
| MM74HCT541WM | SO-20 |
| MM74HCT640WM | SO-20 |
| MM74HCT643WM | SO-20 |
| MM74HCT688WM | SO-20 |

## 74CXXX Series

| Part Number | Package |
|---|---|
| MM74C00M | SO-14 |
| MM74C14M | SO-14 |
| MM74C32M | SO-14 |
| MM74C74M | SO-14 |
| MM74C240WM | SO-20 |
| MM74C244WM | SO-20 |
| MM74C373WM | SO-20 |
| MM74C374WM | SO-20 |
| MM74C901M | SO-14 |
| MM74C906M | SO-14 |
| MM74C914M | SO-14 |
| MM74C923WM | SO-20 |
| MM80C97M | SO-16 |

## LSI/VLSI

| Part Number | Package |
|---|---|
| MM5450V | PCC-44 |
| MM5451V | PCC-44 |
| MM5452V | PCC-44 |
| MM5453V | PCC-44 |
| MM58241V | PCC-44 |
| MM58242V | PCC-28 |
| MM58248V | PCC-44 |
| MM58341V | PCC-44 |
| MM58342V | PCC-28 |
| MM58348V | PCC-44 |

# Logic

## Programmable Array Logic

| Part Number | Package |
|---|---|
| PAL16C1V | PCC-20 |
| PAL16L2V | PCC-20 |
| PAL14L4V | PCC-20 |
| PAL12L6V | PCC-20 |
| PAL10L8V | PCC-20 |
| PAL16H2V | PCC-20 |
| PAL14H4V | PCC-20 |
| PAL10H8V | PCC-20 |
| PAL12H6V | PCC-20 |
| PAL16C1A2V | PCC-20 |
| PAL16L2A2V | PCC-20 |
| PAL14L4A2V | PCC-20 |
| PAL12L6A2V | PCC-20 |
| PAL10L8A2V | PCC-20 |
| PAL16H2A2V | PCC-20 |
| PAL14H4A2V | PCC-20 |
| PAL10H8A2V | PCC-20 |
| PAL12H6A2V | PCC-20 |

| Part Number | Package |
|---|---|
| PAL16L8V | PCC-20 |
| PAL16R4V | PCC-20 |
| PAL16R6V | PCC-20 |
| PAL16R8V | PCC-20 |
| PAL16L8AV | PCC-20 |
| PAL16R4AV | PCC-20 |
| PAL16R6AV | PCC-20 |
| PAL16R8AV | PCC-20 |
| PAL16L8BV | PCC-20 |
| PAL16R4BV | PCC-20 |
| PAL16R6BV | PCC-20 |
| PAL16R8BV | PCC-20 |
| PAL16L8A2V | PCC-20 |
| PAL16R4A2V | PCC-20 |
| PAL16R6A2V | PCC-20 |
| PAL16R8A2V | PCC-20 |
| PAL16L8B2V | PCC-20 |
| PAL16R4B2V | PCC-20 |
| PAL16R6B2V | PCC-20 |
| PAL16R8B2V | PCC-20 |
| PAL16L8B4V | PCC-20 |
| PAL16R4B4V | PCC-20 |
| PAL16R6B4V | PCC-20 |
| PAL16R8B4V | PCC-20 |

| Part Number | Package |
|---|---|
| PAL12L10V | PCC-28 |
| PAL14L8V | PCC-28 |
| PAL16L6V | PCC-28 |
| PAL18L4V | PCC-28 |
| PAL20C1V | PCC-28 |
| PAL20L2V | PCC-28 |
| PAL20L10V | PCC-28 |
| PAL20X10V | PCC-28 |
| PAL20X8V | PCC-28 |
| PAL20X4V | PCC-28 |
| PAL20L8AV | PCC-28 |
| PAL20R8AV | PCC-28 |
| PAL20R6AV | PCC-28 |
| PAL20R4AV | PCC-28 |
| PAL20L8BV | PCC-28 |
| PAL20R8BV | PCC-28 |
| PAL20R6BV | PCC-28 |
| PAL20R4BV | PCC-28 |
| PAL20P8BV | PCC-28 |
| PAL20RP8BV | PCC-28 |
| PAL20RP6BV | PCC-28 |
| PAL20RP4BV | PCC-28 |

## Memory

Density has been one of the driving forces for surface mount technology, and density improvements in memory applications can be substantial. National's MOS memory products, including EEPROMs, are available now and in the near future to satisfy industry demands.

Bipolar programmable array logic based upon TTL is readily available in both 20 and 28-pin PCC packages.

### Bipolar

| Part Number | Package |
|---|---|
| DM74S188V | PCC-20 |
| DM74S188AV | PCC-20 |
| PL87X288BV | PCC-20 |
| DM74S288V | PCC-20 |
| DM74S288AV | PCC-20 |
| DM74S287V | PCC-20 |
| DM74S287AV | PCC-20 |
| DM74S387V | PCC-20 |
| DM74S387AV | PCC-20 |
| DM74S570V | PCC-20 |
| DM74S570AV | PCC-20 |
| DM74S570BV | PCC-20 |
| DM74S571V | PCC-20 |
| DM74S571AV | PCC-20 |
| DM74S571BV | PCC-20 |
| DM74LS471V | PCC-20 |
| DM74S572V | PCC-20 |
| DM74S572AV | PCC-20 |
| DM74S573V | PCC-20 |
| DM74S573AV | PCC-20 |
| DM74S573BV | PCC-20 |
| DM74S472V | PCC-20 |
| DM74S472AV | PCC-20 |
| DM74S472BV | PCC-20 |
| DM74S473V | PCC-20 |
| DM74S473AV | PCC-20 |
| DM87S184V | PCC-20 |
| DM87S184AV | PCC-20 |
| DM87S185V | PCC-20 |
| DM87S185AV | PCC-20 |
| DM87S185BV | PCC-20 |
| DM74S474V | PCC-28 |
| DM74S474AV | PCC-28 |
| DM74S474BV | PCC-28 |
| DM74S475V | PCC-28 |
| DM74S475AV | PCC-28 |
| DM74S475BV | PCC-28 |
| DM87SR474V | PCC-28 |
| DM87SR474BV | PCC-28 |
| DM87SR476V | PCC-28 |
| DM87SR476BV | PCC-28 |
| DM87S180V | PCC-28 |
| DM87S181V | PCC-28 |
| DM87S181AV | PCC-28 |
| DM87LS181V | PCC-28 |
| DM87SR181V | PCC-28 |
| DM87SR183V | PCC-28 |
| DM87SR183AV | PCC-28 |
| DM87S190V | PCC-28 |
| DM87S190AV | PCC-28 |
| DM87S191V | PCC-28 |
| DM87191AV | PCC-28 |
| DM87S191BV | PCC-28 |
| DM87SR191V | PCC-28 |
| DM87SR193V | PCC-28 |
| DM87S321V | PCC-28 |

## Microprocessor

Since LSI functions of the future require high pin count output, National's microprocessor and microcontroller families in surface mount are designed for maximum density, with availability of devices in both PCC and LCC packages.

### 8-Bit

| Part Number | Package |
|---|---|
| NSC800E | LCC-44 |
| NSC800V | PCC-44 |
| NSC810AE | LCC-44 |
| NSC810AV | PCC-44 |
| NSC858E | LCC-28 |
| NSC858V | PCC-44 |
| INS8250AV | PCC-44 |
| INS82C50AV | PCC-44 |
| NS16450V | PCC-44 |
| NS16C450V | PCC-44 |
| MM82PC08V | PCC-28 |
| MM82PC12V | PCC-28 |

### 32-Bit/Series 32000®

| Part Number | Package |
|---|---|
| NS32008V | PCC-68 |
| NS32016V | PCC-68 |
| NS32032V | PCC-68 |
| NS32032E | LCC-68 |
| NS32081V | PCC-44 |
| NS32082V | PCC-68 |
| NS32202V | PCC-44 |
| NS32C016V | PCC-68 |
| NS32C032E | PCC-68 |
| NS32C032V | LCC-68 |
| NS32C201 | PCC-44 |

### Microcontrollers

| Part Number | Package |
|---|---|
| HPC16030E | LCC-68 |
| HPC16030V | PCC-68 |
| HPC16040E | LCC-68 |
| HPC16040V | PCC-68 |
| HPC16083E | LCC-68 |
| HPC16083V | PCC-68 |
| COP411L-XXX/WM | SO-20 |
| COP413L-XXX/WM | SO-20 |
| COP411C-XXX/WM | SO-20 |

## Transistors

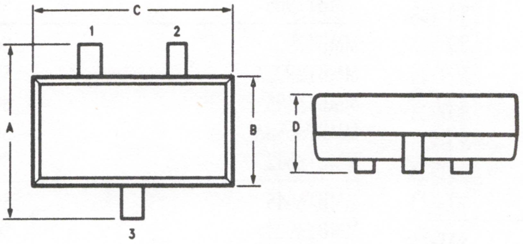
The MMBT and MMBF families of transistors utilize the smallest surface mount package available, the SOT-23. In addition, National is offering a variety of dual channel and higher power devices in the small outline and plastic chip carrier packages for optimum reliability.

| Part Number | Package |
|---|---|
| MMBD914 | SOT-23 |
| MMBD4002 | SOT-23 |
| MMBD4148 | SOT-23 |
| MMBDAV70 | SOT-23 |
| MMBFJ111 | SOT-23 |
| MMBFJ112 | SOT-23 |
| MMBFJ113 | SOT-23 |
| MMBFJ174 | SOT-23 |
| MMBFJ175 | SOT-23 |
| MMBFJ176 | SOT-23 |
| MMBFJ177 | SOT-23 |
| MMBFJ309 | SOT-23 |
| MMBFJ310 | SOT-23 |
| MMBF4391 | SOT-23 |
| MMBF4392 | SOT-23 |
| MMBF4393 | SOT-23 |
| MMBF4416 | SOT-23 |
| MMBF4860 | SOT-23 |
| MMBF4861 | SOT-23 |
| MMBF5457 | SOT-23 |
| MMBF5459 | SOT-23 |
| MMBF5460 | SOT-23 |
| MMBF5484 | SOT-23 |
| MMBF5485 | SOT-23 |
| MMBF5486 | SOT-23 |
| MMBTA05 | SOT-23 |
| MMBTA06 | SOT-23 |
| MMBTA13 | SOT-23 |
| MMBTA20 | SOT-23 |
| MMBTA55 | SOT-23 |
| MMBTA56 | SOT-23 |
| MMBTA70 | SOT-23 |
| MMBTH10 | SOT-23 |
| MMBTH11 | SOT-23 |
| MMBTH20 | SOT-23 |
| MMBTH24 | SOT-23 |
| MMBTH30 | SOT-23 |
| MMBT100 | SOT-23 |
| MMBT100A | SOT-23 |
| MMBT200 | SOT-23 |

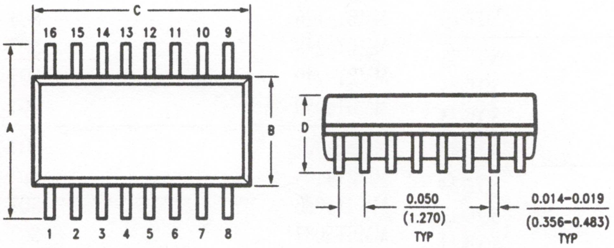
| Part Number | Package |
|---|---|
| MMBT200A | SOT-23 |
| MMBT2222 | SOT-23 |
| MMBT2222A | SOT-23 |
| MMBT2484 | SOT-23 |
| MMBT2905 | SOT-23 |
| MMBT2907 | SOT-23 |
| MMBT2907A | SOT-23 |
| MMBT3393 | SOT-23 |
| MMBT3638A | SOT-23 |
| MMBT3642 | SOT-23 |
| MMBT3645 | SOT-23 |
| MMBT3904 | SOT-23 |
| MMBT3906 | SOT-23 |
| MMBT4123 | SOT-23 |
| MMBT4124 | SOT-23 |
| MMBT4125 | SOT-23 |
| MMBT4126 | SOT-23 |
| MMBT4248 | SOT-23 |
| MMBT4249 | SOT-23 |
| MMBT4250 | SOT-23 |
| MMBT4401 | SOT-23 |
| MMBT4403 | SOT-23 |
| MMBT5086 | SOT-23 |
| MMBT5087 | SOT-23 |
| MMBT5088 | SOT-23 |
| MMBT5089 | SOT-23 |
| MMBT5179 | SOT-23 |
| MMBT5210 | SOT-23 |
| MMBT6515 | SOT-23 |
| MMBT6543 | SOT-23 |
| MMBT918 | SOT-23 |
| NPDS5564 | SO-8 |
| NPDS5565 | SO-8 |
| NPDS5566 | SO-8 |
| NPDS5911 | SO-8 |
| NPDS5912 | SO-8 |

## Physical Dimensions inches (millimeters)

SOT-23



SO Narrow

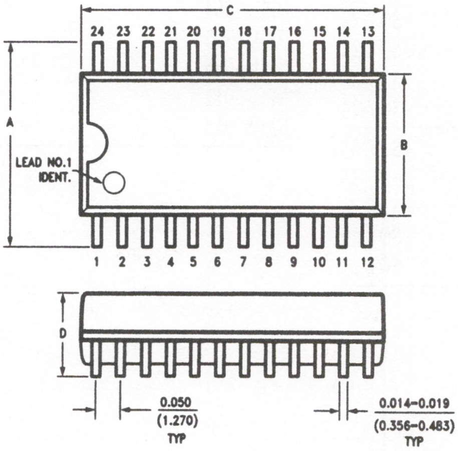

C
16 15 14 13 12 11 10 9
A
B
D
1 2 3 4 5 6 7 8
0.050
(1.270)
TYP
0.014–0.019
(0.356–0.483)
TYP

### SO "M" Package (Narrow Body)

| Lead Count | Dimensions inches (mm) A Min | A Max | B Min | B Max | C Min | C Max | D Min | D Max |
|---|---|---|---|---|---|---|---|---|
| 3 | 0.083<br>(2.108) | 0.098<br>(2.489) | 0.047<br>(1.194) | 0.055<br>(1.397) | 0.110<br>(2.794) | 0.120<br>(3.048) | (a) 0.031<br>(0.787)<br>(b) 0.027<br>(0.689) | 0.047<br>(1.397)<br>0.041<br>(1.041) |
| 8 | 0.228<br>(5.791) | 0.244<br>(6.198) | 0.150<br>(3.810) | 0.158<br>(4.013) | 0.188<br>(4.775) | 0.196<br>(4.978) | 0.053<br>(1.346) | 0.069<br>(1.753) |
| 14 | 0.228<br>(5.791) | 0.244<br>(6.198) | 0.150<br>(3.810) | 0.158<br>(4.013) | 0.336<br>(8.534) | 0.344<br>(8.738) | 0.053<br>(1.346) | 0.069<br>(1.753) |
| 16 | 0.228<br>(5.791) | 0.244<br>(6.198) | 0.150<br>(3.810) | 0.158<br>(4.013) | 0.385<br>(9.779) | 0.394<br>(10.01) | 0.053<br>(1.346) | 0.069<br>(1.753) |

(a) SOT-23 High Profile (b) SOT-23 Low Profile

SO Wide

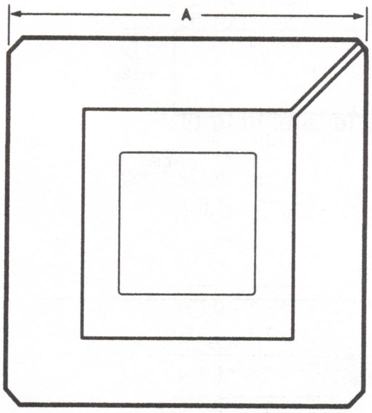

C
24 23 22 21 20 19 18 17 16 15 14 13
A
LEAD NO.1
IDENT.
B
1 2 3 4 5 6 7 8 9 10 11 12
D
0.050
(1.270)
TYP
0.014–0.019
(0.356–0.483)
TYP

### SO "M" Package (Wide Body)

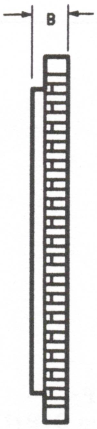
| Lead Count | Dimensions inches (mm) A Min | A Max | B Min | B Max | C Min | C Max | D Min | D Max |
|---|---|---|---|---|---|---|---|---|
| 14W | 0.394<br>(10.01) | 0.419<br>(10.64) | 0.291<br>(7.391) | 0.299<br>(7.595) | 0.346<br>(8.788) | 0.362<br>(9.195) | 0.093<br>(2.362) | 0.104<br>(2.642) |
| 16W | 0.394<br>(10.01) | 0.419<br>(10.64) | 0.291<br>(7.391) | 0.299<br>(7.595) | 0.346<br>(8.788) | 0.412<br>(10.46) | 0.093<br>(2.362) | 0.104<br>(2.642) |
| 20 | 0.394<br>(10.01) | 0.419<br>(10.64) | 0.291<br>(7.391) | 0.299<br>(7.595) | 0.496<br>(12.60) | 0.512<br>(13.01) | 0.093<br>(2.362) | 0.104<br>(2.642) |
| 24 | 0.394<br>(10.01) | 0.419<br>(10.64) | 0.291<br>(7.391) | 0.299<br>(7.595) | 0.596<br>(15.14) | 0.612<br>(15.54) | 0.093<br>(2.362) | 0.104<br>(2.642) |

## Physical Dimensions inches (millimeters)

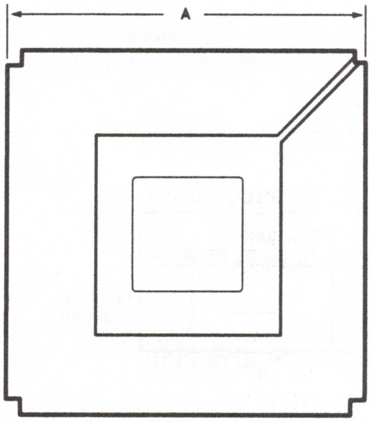
**Top View**
**LCC-28**
**LCC-44**



**Side View**
**All**



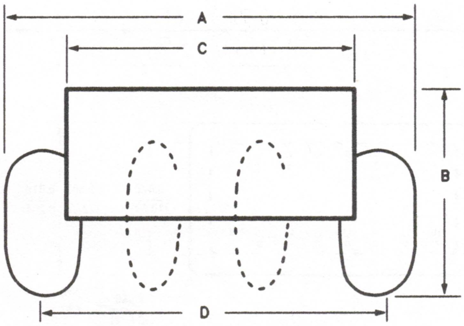
**Top View**
**LCC-68**
**LCC-84**
**LCC-124**



### LCC "E" Package

| Lead Count | Dimensions inches (mm) A Min | A Max | B Min | B Max |
|---|---|---|---|---|
| 28 | 0.442<br>(11.23) | 0.458<br>(11.63) | 0.065<br>(1.651) | 0.076<br>(1.930) |
| 44 | 0.640<br>(16.256) | 0.660<br>(16.764) | 0.065<br>(1.651) | 0.076<br>(1.930) |
| 68 | 0.940<br>(23.876) | 0.960<br>(24.384) | 0.069<br>(1.753) | 0.085<br>(2.159) |
| 84 | 1.139<br>(28.931) | 1.161<br>(29.489) | 0.070<br>(1.778) | 0.078<br>(1.981) |
| 124 | 1.642<br>(41.707) | 1.658<br>(42.113) | 0.092<br>(2.337) | 0.100<br>(2.54) |

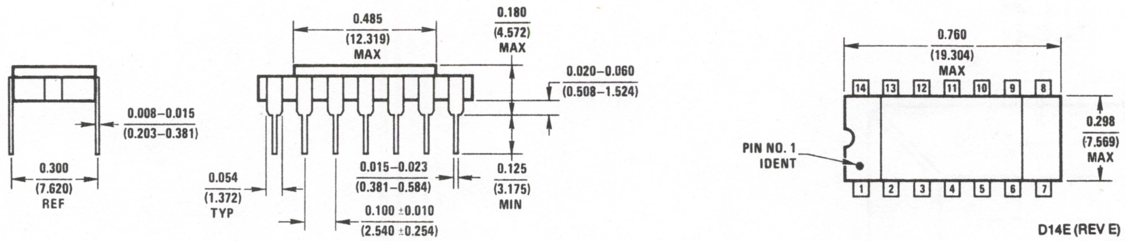
**PCC**



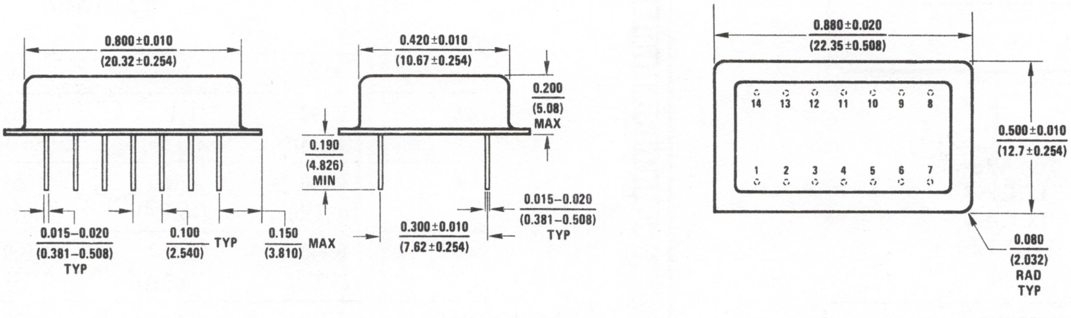
### PCC "V" Package

| Lead Count | Dimensions inches (mm) A Min | A Max | B Min | B Max | C Min | C Max | D Min | D Max |
|---|---|---|---|---|---|---|---|---|
| 20 | 0.385<br>(9.779) | 0.395<br>(10.03) | 0.165<br>(4.191) | 0.180<br>(4.572) | 0.345<br>(8.763) | 0.355<br>(9.017) | 0.310<br>(7.874) | 0.330<br>(8.382) |
| 28 | 0.485<br>(12.32) | 0.495<br>(12.57) | 0.165<br>(4.191) | 0.180<br>(4.572) | 0.445<br>(11.30) | 0.455<br>(11.56) | 0.410<br>(10.41) | 0.430<br>(10.92) |
| 44 | 0.685<br>(17.40) | 0.695<br>(17.65) | 0.165<br>(4.191) | 0.180<br>(4.572) | 0.645<br>(16.38) | 0.655<br>(16.64) | 0.610<br>(15.49) | 0.630<br>(16.00) |
| 68 | 0.985<br>(25.02) | 0.995<br>(25.27) | 0.165<br>(4.191) | 0.180<br>(4.572) | 0.945<br>(24.00) | 0.955<br>(24.26) | 0.910<br>(23.11) | 0.930<br>(23.62) |
| 84 | 1.185<br>(30.10) | 1.195<br>(30.36) | 0.165<br>(4.191) | 0.180<br>(4.572) | 1.150<br>(29.21) | 1.158<br>(29.41) | 1.110<br>(28.20) | 1.130<br>(28.70) |
| 124 | 1.685<br>(49.13) | 1.695<br>(49.39) | 0.180<br>(4.572) | 0.200<br>(5.080) | 1.650<br>(41.91) | 1.658<br>(42.11) | 1.610<br>(40.90) | 1.630<br>(41.40) |

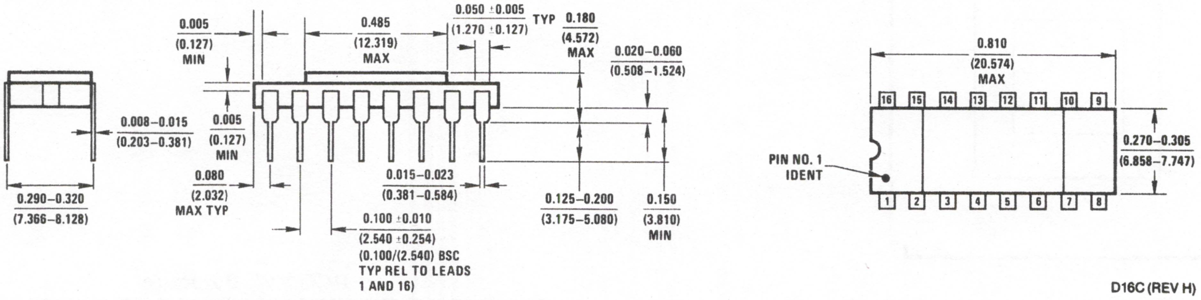
## Physical Dimensions inches (millimeters)


0.485
(12.319)
MAX
0.180
(4.572)
MAX
0.020–0.060
(0.508–1.524)
0.008–0.015
(0.203–0.381)
0.300
(7.620)
REF
0.054
(1.372)
TYP
0.015–0.023
(0.381–0.584)
0.125
(3.175)
MIN
0.100 ±0.010
(2.540 ±0.254)
0.760
(19.304)
MAX
14 13 12 11 10 9 8
1 2 3 4 5 6 7
PIN NO. 1
IDENT
0.298
(7.569)
MAX
D14E (REV E)

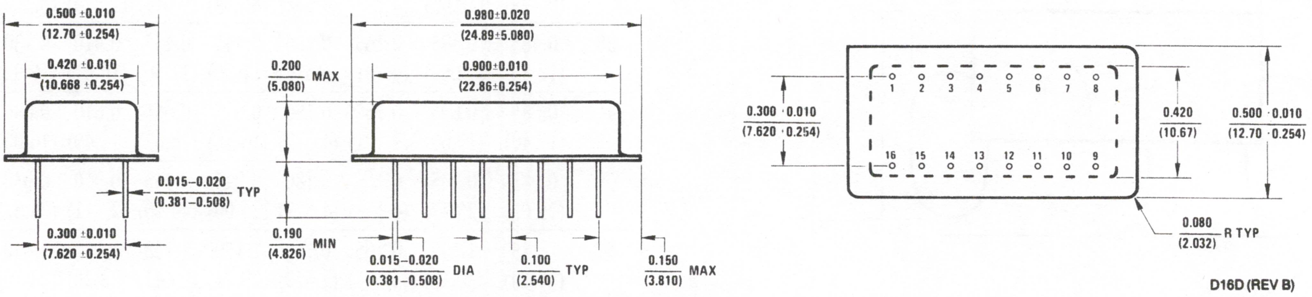
**NS Package D14E**
**14-Lead Hermetic DIP (D)**


0.800±0.010
(20.32±0.254)
0.420±0.010
(10.67±0.254)
0.200
(5.08)
MAX
0.190
(4.826)
MIN
0.015–0.020
(0.381–0.508)
TYP
0.100
(2.540)
TYP
0.150
(3.810)
MAX
0.300±0.010
(7.62±0.254)
0.015–0.020
(0.381–0.508)
TYP
0.880±0.020
(22.35±0.508)
14 13 12 11 10 9 8
1 2 3 4 5 6 7
0.500±0.010
(12.7±0.254)
0.080
(2.032)
RAD
TYP
D14F (REV A)

**NS Package D14F**
**14-Lead Hybrid Metal Can DIP (D)**

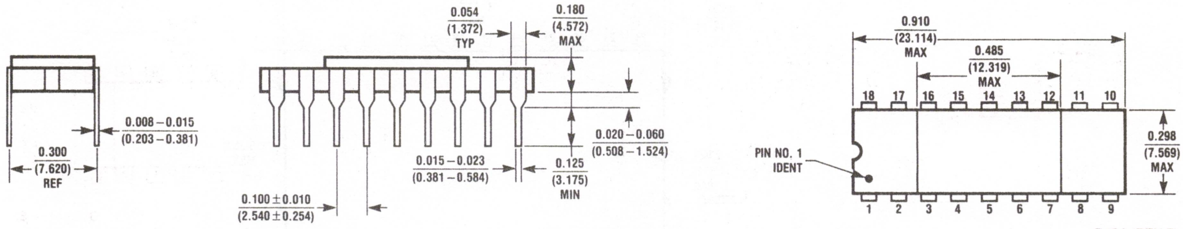

0.005
(0.127)
MIN
0.485
(12.319)
MAX
0.050 ±0.005
(1.270 ±0.127)
TYP
0.180
(4.572)
MAX
0.020–0.060
(0.508–1.524)
0.008–0.015
(0.203–0.381)
0.005
(0.127)
MIN
0.080
(2.032)
MAX TYP
0.015–0.023
(0.381–0.584)
0.100 ±0.010
(2.540 ±0.254)
(0.100/(2.540) BSC
TYP REL TO LEADS
1 AND 16)
0.125–0.200
(3.175–5.080)
0.150
(3.810)
MIN
0.290–0.320
(7.366–8.128)
0.810
(20.574)
MAX
16 15 14 13 12 11 10 9
1 2 3 4 5 6 7 8
PIN NO. 1
IDENT
0.270–0.305
(6.858–7.747)
D16C (REV H)

**NS Package D16C**
**16-Lead Hermetic DIP (D)**

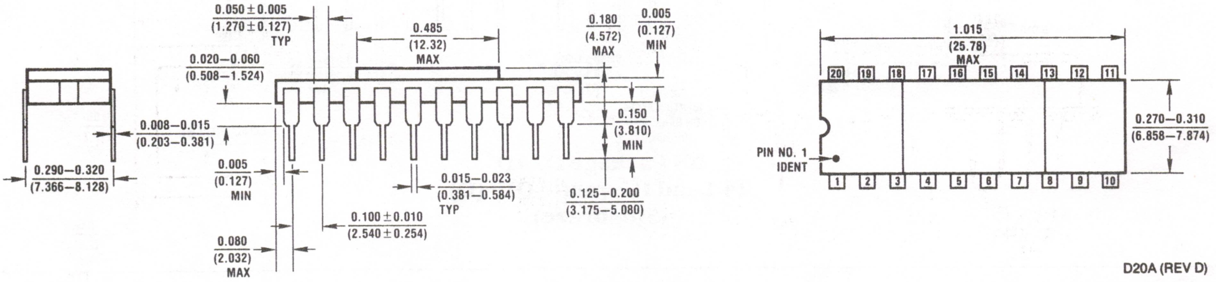

0.500 ±0.010
(12.70 ±0.254)
0.420 ±0.010
(10.668 ±0.254)
0.015–0.020
(0.381–0.508)
TYP
0.300 ±0.010
(7.620 ±0.254)
0.200
(5.080)
MAX
0.190
(4.826)
MIN
0.980±0.020
(24.89±5.080)
0.900±0.010
(22.86±0.254)
0.015–0.020
(0.381–0.508)
DIA
0.100
(2.540)
TYP
0.150
(3.810)
MAX
1 2 3 4 5 6 7 8
16 15 14 13 12 11 10 9
0.300 ±0.010
(7.620 ±0.254)
0.420
(10.67)
0.500 ±0.010
(12.70 ±0.254)
0.080
(2.032)
R TYP
D16D (REV B)

**NS Package D16D**
**16-Lead Hybrid Metal Can DIP (D)**

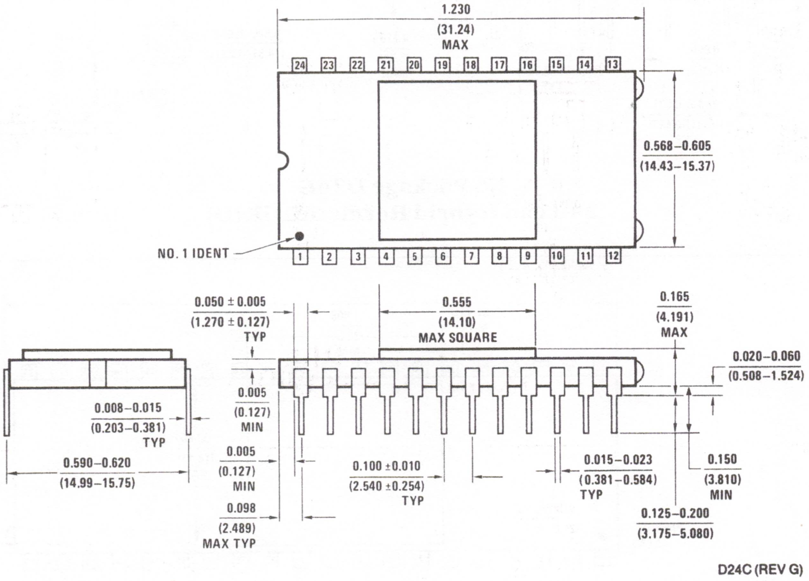
## **Physical Dimensions** inches (millimeters)


0.054
(1.372)
TYP
0.180
(4.572)
MAX
0.008 – 0.015
(0.203 – 0.381)
0.300
(7.620)
REF
0.020 – 0.060
(0.508 – 1.524)
0.015 – 0.023
(0.381 – 0.584)
0.125
(3.175)
MIN
0.100 ± 0.010
(2.540 ± 0.254)
0.910
(23.114)
MAX
0.485
(12.319)
MAX
18 17 16 15 14 13 12 11 10
PIN NO. 1
IDENT
0.298
(7.569)
MAX
1 2 3 4 5 6 7 8 9
D18A (REV E)

**NS Package D18A**
**18-Lead Hermetic DIP (D)**

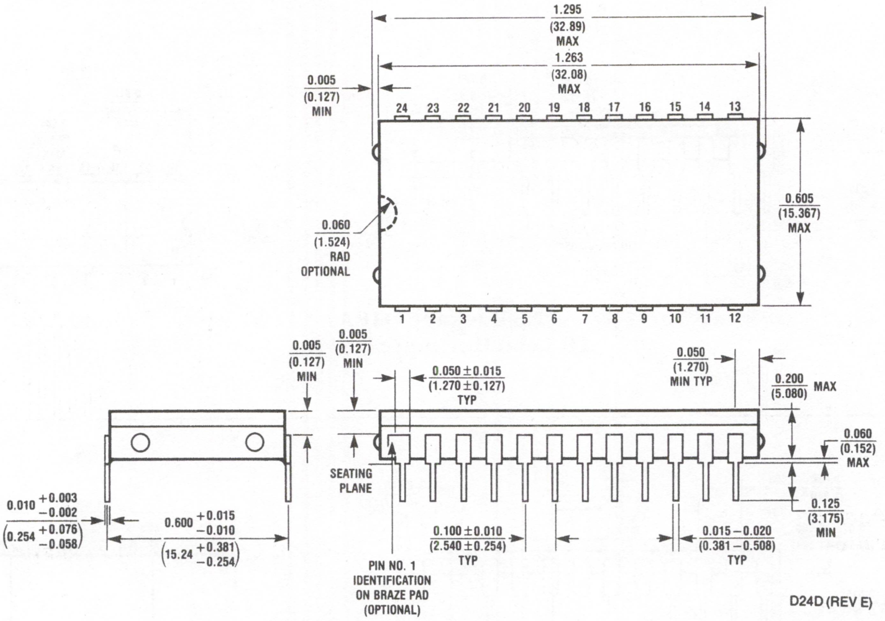

0.050 ± 0.005
(1.270 ± 0.127)
TYP
0.485
(12.32)
MAX
0.180
(4.572)
MAX
0.005
(0.127)
MIN
0.020–0.060
(0.508–1.524)
0.008–0.015
(0.203–0.381)
0.150
(3.810)
MIN
0.290–0.320
(7.366–8.128)
0.005
(0.127)
MIN
0.015–0.023
(0.381–0.584)
TYP
0.125–0.200
(3.175–5.080)
0.100 ± 0.010
(2.540 ± 0.254)
0.080
(2.032)
MAX
1.015
(25.78)
MAX
20 19 18 17 16 15 14 13 12 11
PIN NO. 1
IDENT
0.270–0.310
(6.858–7.874)
1 2 3 4 5 6 7 8 9 10
D20A (REV D)

**NS Package D20A**
**20-Lead Hermetic DIP (D)**


1.230
(31.24)
MAX
24 23 22 21 20 19 18 17 16 15 14 13
0.568–0.605
(14.43–15.37)
NO. 1 IDENT
1 2 3 4 5 6 7 8 9 10 11 12
0.050 ± 0.005
(1.270 ± 0.127)
TYP
0.555
(14.10)
MAX SQUARE
0.165
(4.191)
MAX
0.020–0.060
(0.508–1.524)
0.005
(0.127)
MIN
0.008–0.015
(0.203–0.381)
TYP
0.590–0.620
(14.99–15.75)
0.005
(0.127)
MIN
0.100 ± 0.010
(2.540 ± 0.254)
TYP
0.015–0.023
(0.381–0.584)
TYP
0.150
(3.810)
MIN
0.098
(2.489)
MAX TYP
0.125–0.200
(3.175–5.080)
D24C (REV G)

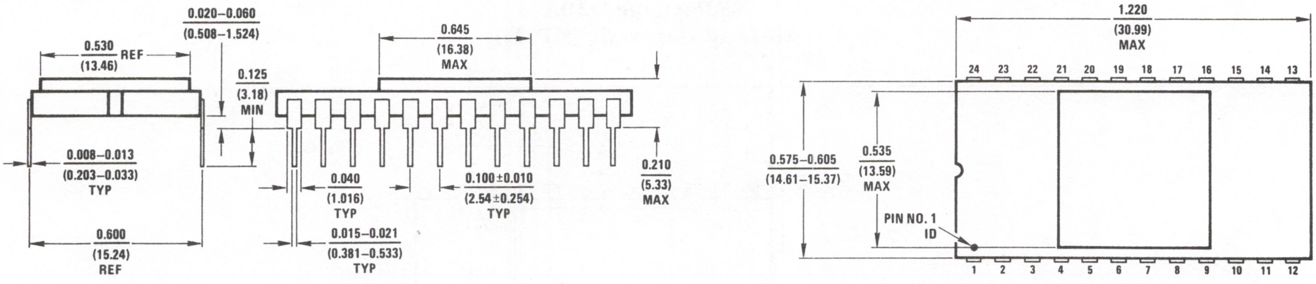
**NS Package D24C**
**24-Lead Hermetic DIP (D)**

# Physical Dimensions inches (millimeters)


1.295 (32.89) MAX
1.263 (32.08) MAX
0.005 (0.127) MIN
24 23 22 21 20 19 18 17 16 15 14 13
0.060 (1.524) RAD OPTIONAL
0.605 (15.367) MAX
1 2 3 4 5 6 7 8 9 10 11 12
0.005 (0.127) MIN
0.005 (0.127) MIN
0.050 ± 0.015 (1.270 ± 0.127) TYP
0.050 (1.270) MIN TYP
0.200 (5.080) MAX
0.060 (0.152) MAX
SEATING PLANE
0.010 +0.003 −0.002 (0.254 +0.076 −0.058)
0.600 +0.015 −0.010 (15.24 +0.381 −0.254)
0.125 (3.175) MIN
0.100 ± 0.010 (2.540 ± 0.254) TYP
0.015 − 0.020 (0.381 − 0.508) TYP
PIN NO. 1 IDENTIFICATION ON BRAZE PAD (OPTIONAL)

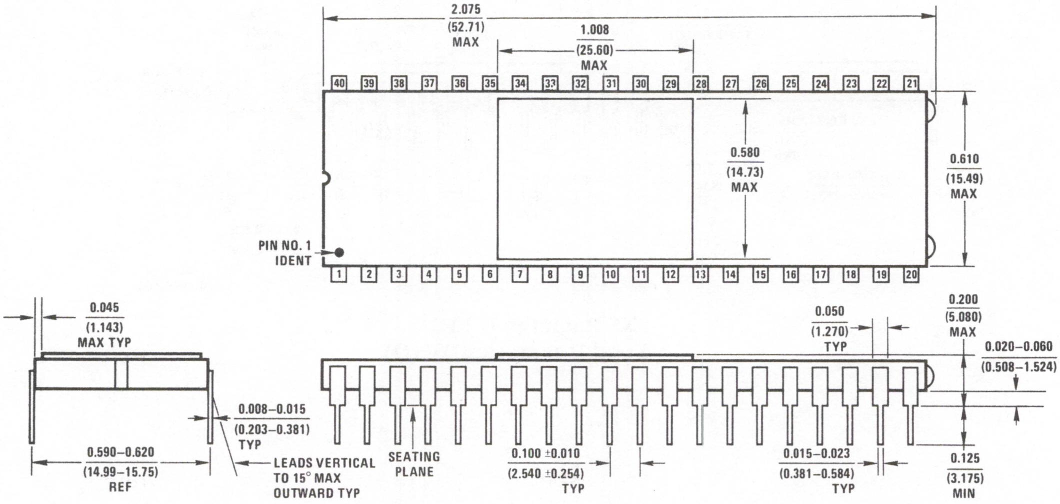
D24D (REV E)

**NS Package D24D**
**24-Lead Hermetic DIP (D)**
**(Sidebraze)**


0.020–0.060 (0.508–1.524)
0.530 (13.46) REF
0.125 (3.18) MIN
0.645 (16.38) MAX
0.008–0.013 (0.203–0.033) TYP
0.040 (1.016) TYP
0.100±0.010 (2.54±0.254) TYP
0.210 (5.33) MAX
0.015–0.021 (0.381–0.533) TYP
0.600 (15.24) REF
1.220 (30.99) MAX
24 23 22 21 20 19 18 17 16 15 14 13
0.575–0.605 (14.61–15.37)
0.535 (13.59) MAX
PIN NO. 1 ID
1 2 3 4 5 6 7 8 9 10 11 12

D24G (REV B)

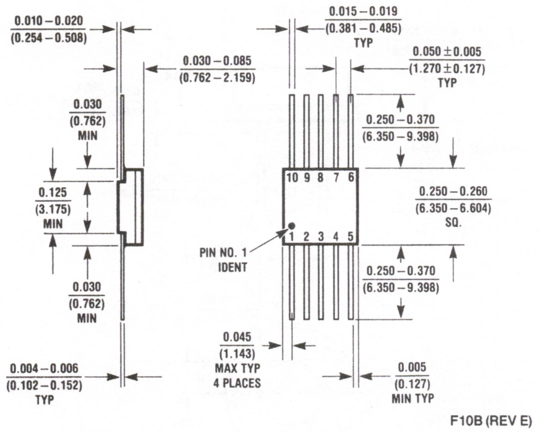
**NS Package D24G**
**24-Lead Hybrid Hermetic DIP (D)**


2.075 (52.71) MAX
1.008 (25.60) MAX
40 39 38 37 36 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21
0.580 (14.73) MAX
0.610 (15.49) MAX
PIN NO. 1 IDENT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
0.045 (1.143) MAX TYP
0.050 (1.270) TYP
0.200 (5.080) MAX
0.020–0.060 (0.508–1.524)
0.008–0.015 (0.203–0.381) TYP
0.590–0.620 (14.99–15.75) REF
LEADS VERTICAL TO 15° MAX OUTWARD TYP
SEATING PLANE
0.100 ±0.010 (2.540 ±0.254) TYP
0.015–0.023 (0.381–0.584) TYP
0.125 (3.175) MIN

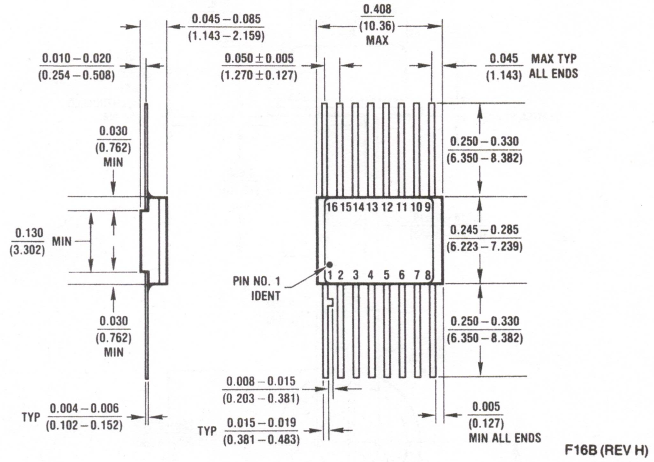
D40C (REV H)

**NS Package D40C**
**40-Lead Hermetic DIP (D)**

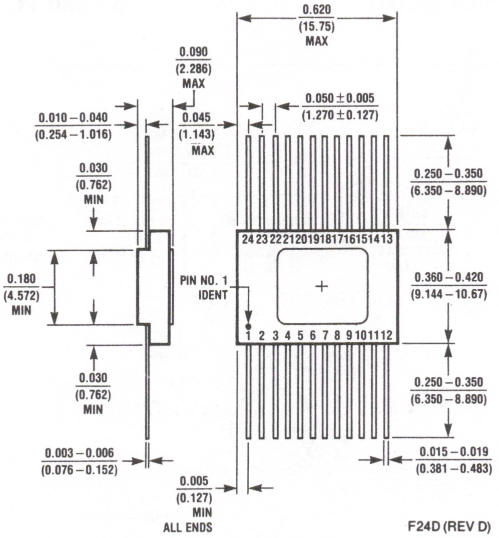
# Physical Dimensions inches (millimeters)


0.010 – 0.020 (0.254 – 0.508)
0.015 – 0.019 (0.381 – 0.485) TYP
0.050 ± 0.005 (1.270 ± 0.127) TYP
0.030 – 0.085 (0.762 – 2.159)
0.030 (0.762) MIN
0.250 – 0.370 (6.350 – 9.398)
10 9 8 7 6
0.125 (3.175) MIN
0.250 – 0.260 (6.350 – 6.604) SQ.
PIN NO. 1 IDENT
1 2 3 4 5
0.250 – 0.370 (6.350 – 9.398)
0.030 (0.762) MIN
0.045 (1.143) MAX TYP 4 PLACES
0.004 – 0.006 (0.102 – 0.152) TYP
0.005 (0.127) MIN TYP
F10B (REV E)

**NS Package F10B**
**10-Lead Ceramic Flat Package (F)**

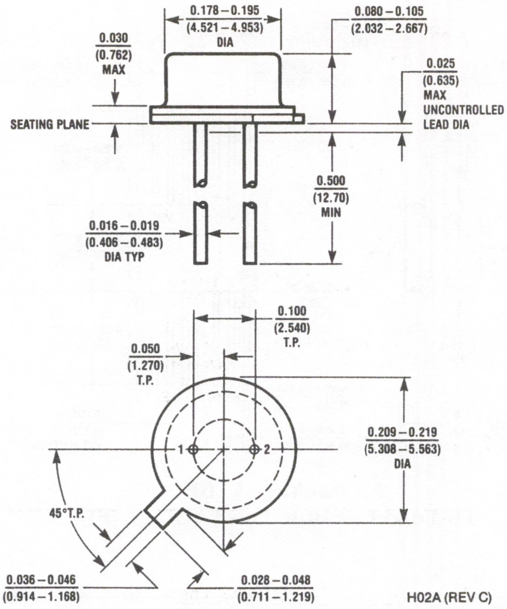

0.045 – 0.085 (1.143 – 2.159)
0.408 (10.36) MAX
0.010 – 0.020 (0.254 – 0.508)
0.050 ± 0.005 (1.270 ± 0.127)
0.045 (1.143) MAX TYP ALL ENDS
0.030 (0.762) MIN
0.250 – 0.330 (6.350 – 8.382)
16 15 14 13 12 11 10 9
0.130 (3.302) MIN
0.245 – 0.285 (6.223 – 7.239)
PIN NO. 1 IDENT
1 2 3 4 5 6 7 8
0.030 (0.762) MIN
0.250 – 0.330 (6.350 – 8.382)
0.008 – 0.015 (0.203 – 0.381)
TYP 0.004 – 0.006 (0.102 – 0.152)
TYP 0.015 – 0.019 (0.381 – 0.483)
0.005 (0.127) MIN ALL ENDS
F16B (REV H)

**NS Package F16B**
**16-Lead Ceramic Flat Package (F)**

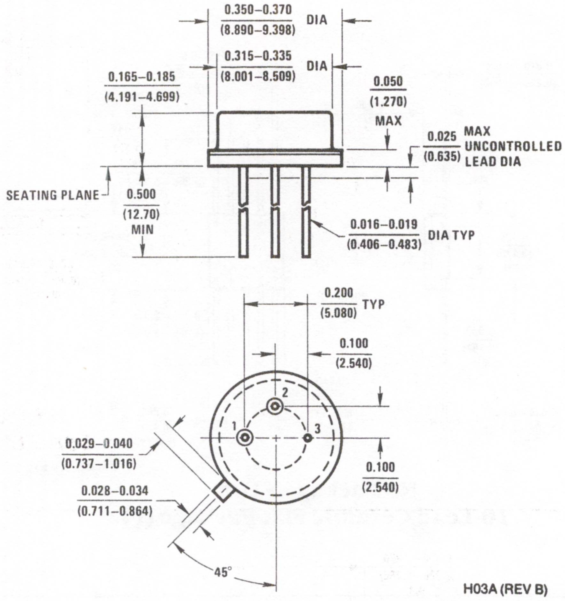

0.620 (15.75) MAX
0.090 (2.286) MAX
0.010 – 0.040 (0.254 – 1.016)
0.045 (1.143) MAX
0.050 ± 0.005 (1.270 ± 0.127)
0.030 (0.762) MIN
0.250 – 0.350 (6.350 – 8.890)
24 23 22 21 20 19 18 17 16 15 14 13
0.180 (4.572) MIN
PIN NO. 1 IDENT
0.360 – 0.420 (9.144 – 10.67)
1 2 3 4 5 6 7 8 9 10 11 12
0.030 (0.762) MIN
0.250 – 0.350 (6.350 – 8.890)
0.003 – 0.006 (0.076 – 0.152)
0.015 – 0.019 (0.381 – 0.483)
0.005 (0.127) MIN ALL ENDS
F24D (REV D)

**NS Package F24D**
**24-Lead Ceramic Flat Package (F)**

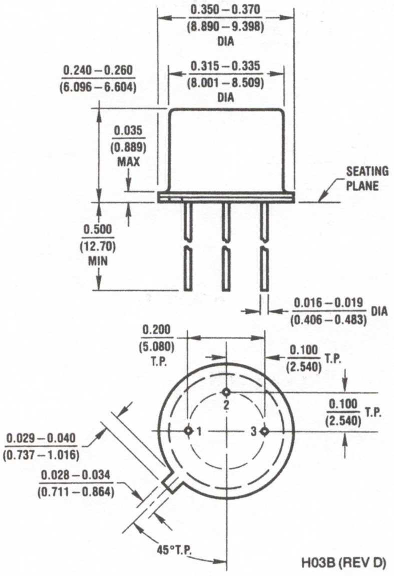
# Physical Dimensions inches (millimeters)


0.178 – 0.195
(4.521 – 4.953)
DIA
0.080 – 0.105
(2.032 – 2.667)
0.030
(0.762)
MAX
0.025
(0.635)
MAX
UNCONTROLLED
LEAD DIA
SEATING PLANE
0.500
(12.70)
MIN
0.016 – 0.019
(0.406 – 0.483)
DIA TYP
0.100
(2.540)
T.P.
0.050
(1.270)
T.P.
1
2
0.209 – 0.219
(5.308 – 5.563)
DIA
45°T.P.
0.036 – 0.046
(0.914 – 1.168)
0.028 – 0.048
(0.711 – 1.219)
H02A (REV C)

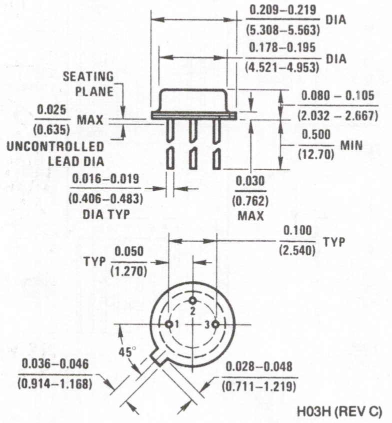
**NS Package H02A**
**2-Lead TO-46 Metal Can Package (H)**


0.350–0.370
(8.890–9.398)
DIA
0.315–0.335
(8.001–8.509)
DIA
0.165–0.185
(4.191–4.699)
0.050
(1.270)
MAX
0.025 MAX
(0.635) UNCONTROLLED
LEAD DIA
SEATING PLANE
0.500
(12.70)
MIN
0.016–0.019
(0.406–0.483)
DIA TYP
0.200
(5.080)
TYP
0.100
(2.540)
2
1
3
0.029–0.040
(0.737–1.016)
0.028–0.034
(0.711–0.864)
0.100
(2.540)
45°
H03A (REV B)

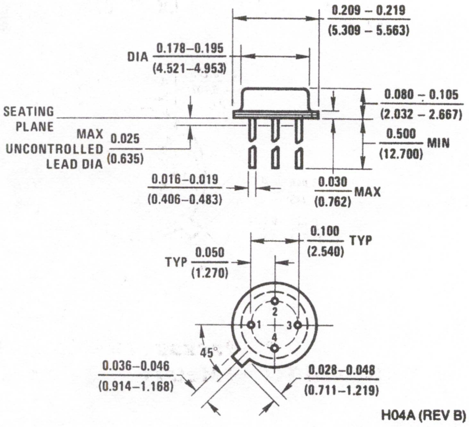
**NS Package H03A**
**3-Lead TO-39 Metal Can Package (H)**


0.350 – 0.370
(8.890 – 9.398)
DIA
0.240 – 0.260
(6.096 – 6.604)
0.315 – 0.335
(8.001 – 8.509)
DIA
0.035
(0.889)
MAX
SEATING
PLANE
0.500
(12.70)
MIN
0.016 – 0.019
(0.406 – 0.483)
DIA
0.200
(5.080)
T.P.
0.100
(2.540)
T.P.
2
1
3
0.100
(2.540)
T.P.
0.029 – 0.040
(0.737 – 1.016)
0.028 – 0.034
(0.711 – 0.864)
45°T.P.
H03B (REV D)

**NS Package H03B**
**3-Lead TO-39 Metal Can Package (H)**

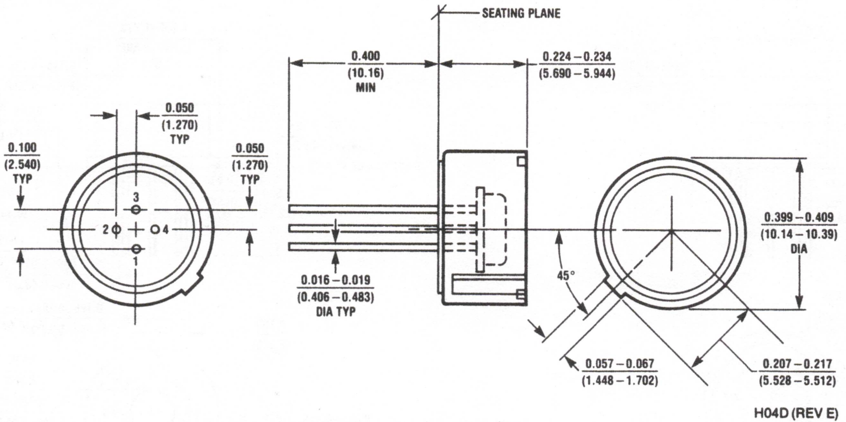

0.209–0.219
(5.308–5.563)
DIA
0.178–0.195
(4.521–4.953)
DIA
SEATING
PLANE
0.025
(0.635)
MAX
UNCONTROLLED
LEAD DIA
0.080 – 0.105
(2.032 – 2.667)
0.500
(12.70)
MIN
0.016–0.019
(0.406–0.483)
DIA TYP
0.030
(0.762)
MAX
0.100
(2.540)
TYP
0.050
(1.270)
TYP
2
1
3
45°
0.036–0.046
(0.914–1.168)
0.028–0.048
(0.711–1.219)
H03H (REV C)

**NS Package H03H**
**3-Lead TO-46 Metal Can Package (H)**

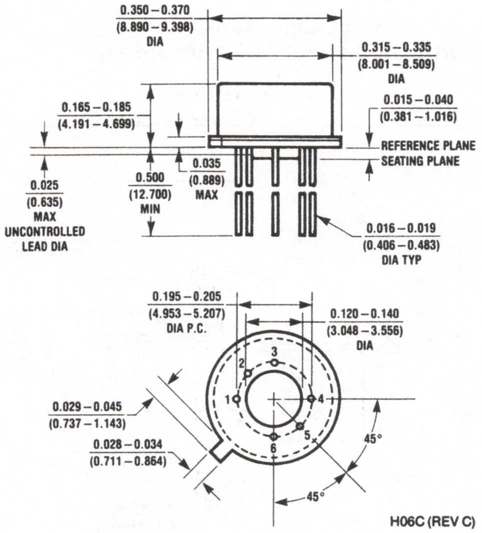

0.209 – 0.219
(5.309 – 5.563)
DIA
0.178–0.195
(4.521–4.953)
SEATING
PLANE
MAX
UNCONTROLLED
LEAD DIA
0.025
(0.635)
0.080 – 0.105
(2.032 – 2.667)
0.500
(12.700)
MIN
0.016–0.019
(0.406–0.483)
0.030
(0.762)
MAX
0.100
(2.540)
TYP
0.050
(1.270)
TYP
2
1
3
4
45°
0.036–0.046
(0.914–1.168)
0.028–0.048
(0.711–1.219)
H04A (REV B)

**NS Package H04A**
**4-Lead TO-46 Metal Can Package (H)**

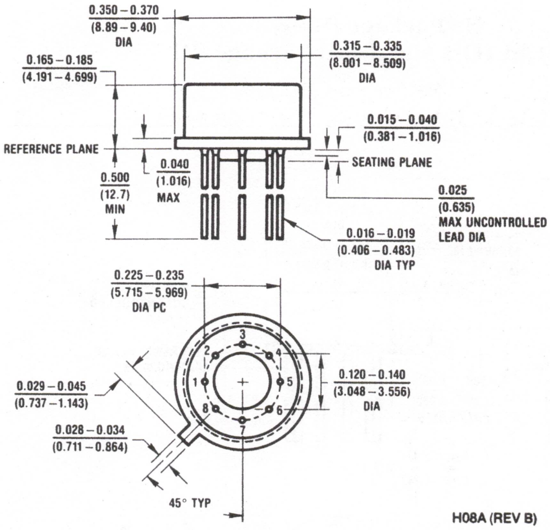
## Physical Dimensions inches (millimeters)


SEATING PLANE
0.400
(10.16)
MIN
0.224 – 0.234
(5.690 – 5.944)
0.050
(1.270)
TYP
0.100
(2.540)
TYP
0.050
(1.270)
TYP
3
2
4
1
0.399 – 0.409
(10.14 – 10.39)
DIA
45°
0.016 – 0.019
(0.406 – 0.483)
DIA TYP
0.057 – 0.067
(1.448 – 1.702)
0.207 – 0.217
(5.528 – 5.512)
H04D (REV E)

**NS Package H04D**
**Thermal Shield Metal Can Package (H)**

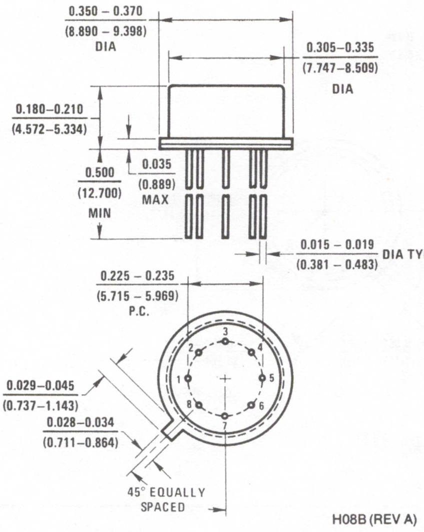

0.350 – 0.370
(8.890 – 9.398)
DIA
0.315 – 0.335
(8.001 – 8.509)
DIA
0.015 – 0.040
(0.381 – 1.016)
0.165 – 0.185
(4.191 – 4.699)
REFERENCE PLANE
SEATING PLANE
0.035
(0.889)
MAX
0.025
(0.635)
MAX
UNCONTROLLED
LEAD DIA
0.500
(12.700)
MIN
0.016 – 0.019
(0.406 – 0.483)
DIA TYP
0.195 – 0.205
(4.953 – 5.207)
DIA P.C.
0.120 – 0.140
(3.048 – 3.556)
DIA
1
2
3
4
5
6
0.029 – 0.045
(0.737 – 1.143)
0.028 – 0.034
(0.711 – 0.864)
45°
45°
H06C (REV C)

**NS Package H06C**
**6-Lead TO-99 Metal Can Package (H)**

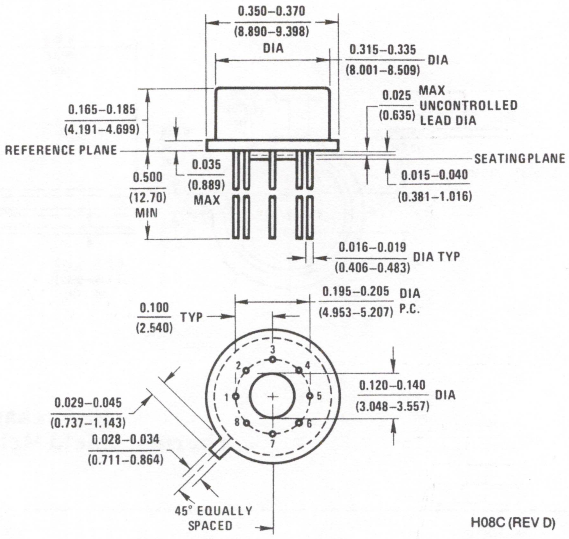

0.350 – 0.370
(8.89 – 9.40)
DIA
0.315 – 0.335
(8.001 – 8.509)
DIA
0.165 – 0.185
(4.191 – 4.699)
0.015 – 0.040
(0.381 – 1.016)
REFERENCE PLANE
SEATING PLANE
0.040
(1.016)
MAX
0.500
(12.7)
MIN
0.025
(0.635)
MAX UNCONTROLLED
LEAD DIA
0.016 – 0.019
(0.406 – 0.483)
DIA TYP
0.225 – 0.235
(5.715 – 5.969)
DIA PC
1
2
3
4
5
6
7
8
0.120 – 0.140
(3.048 – 3.556)
DIA
0.029 – 0.045
(0.737 – 1.143)
0.028 – 0.034
(0.711 – 0.864)
45° TYP
H08A (REV B)

**NS Package H08A**
**8-Lead TO-5 Metal Can Package (H)**

## Physical Dimensions inches (millimeters)


0.350 – 0.370
(8.890 – 9.398)
DIA
0.305–0.335
(7.747–8.509)
DIA
0.180–0.210
(4.572–5.334)
0.035
(0.889)
MAX
0.500
(12.700)
MIN
0.015 – 0.019
(0.381 – 0.483)
DIA TYP
0.225 – 0.235
(5.715 – 5.969)
P.C.
0.029–0.045
(0.737–1.143)
0.028–0.034
(0.711–0.864)
45° EQUALLY
SPACED
1
2
3
4
5
6
7
8
H08B (REV A)

**NS Package H08B**
**8-Lead TO-5 Metal Can Package (H)**


0.350–0.370
(8.890–9.398)
DIA
0.315–0.335
(8.001–8.509)
DIA
0.025
(0.635)
MAX
UNCONTROLLED
LEAD DIA
0.165–0.185
(4.191–4.699)
REFERENCE PLANE
SEATING PLANE
0.035
(0.889)
MAX
0.500
(12.70)
MIN
0.015–0.040
(0.381–1.016)
0.016–0.019
(0.406–0.483)
DIA TYP
0.100
(2.540)
TYP
0.195–0.205
(4.953–5.207)
DIA
P.C.
0.120–0.140
(3.048–3.557)
DIA
0.029–0.045
(0.737–1.143)
0.028–0.034
(0.711–0.864)
45° EQUALLY
SPACED
1
2
3
4
5
6
7
8
H08C (REV D)

**NS Package H08C**
**8-Lead TO-99 Metal Can Package (H)**

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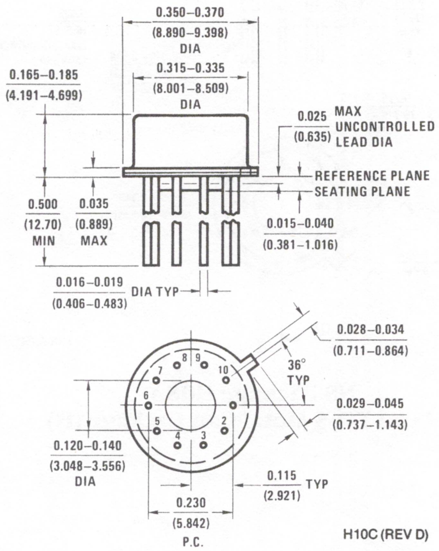
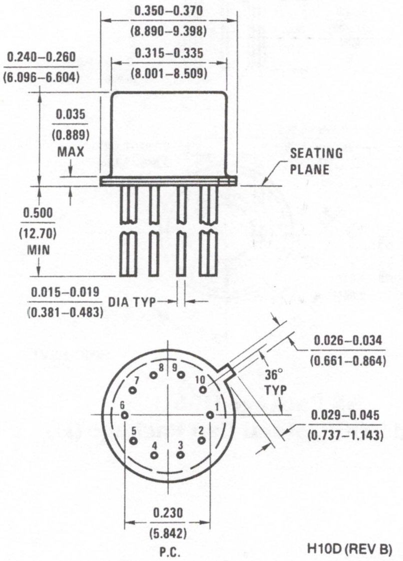
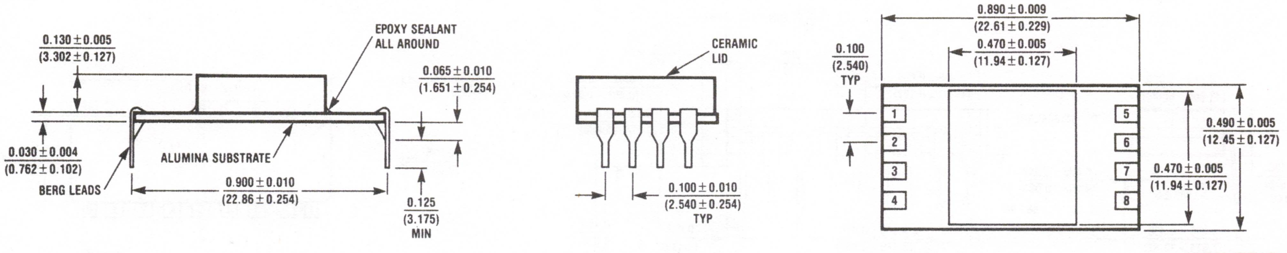

0.350–0.370
(8.890–9.398)
DIA
0.315–0.335
(8.001–8.509)
DIA
0.165–0.185
(4.191–4.699)
0.025
(0.635)
MAX
UNCONTROLLED
LEAD DIA
REFERENCE PLANE
SEATING PLANE
0.500
(12.70)
MIN
0.035
(0.889)
MAX
0.015–0.040
(0.381–1.016)
0.016–0.019
(0.406–0.483)
DIA TYP
0.028–0.034
(0.711–0.864)
36°
TYP
0.029–0.045
(0.737–1.143)
0.120–0.140
(3.048–3.556)
DIA
0.115
(2.921)
TYP
0.230
(5.842)
P.C.
1
2
3
4
5
6
7
8
9
10
H10C (REV D)

**NS Package H10C**
**10-Lead TO-100 Metal Can Package (H)**

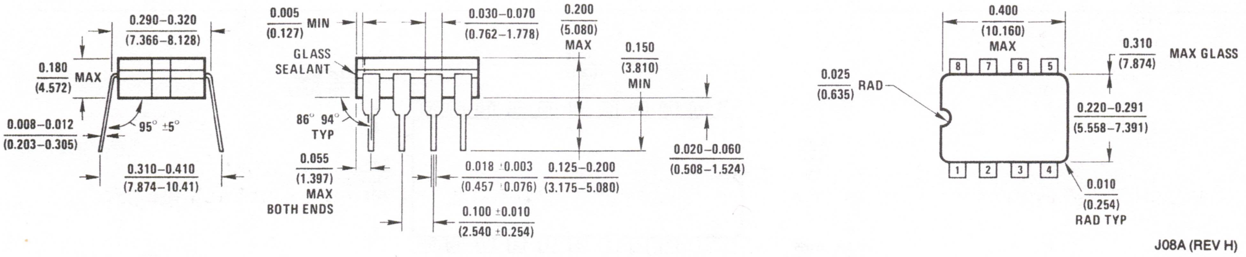

0.350–0.370
(8.890–9.398)
0.240–0.260
(6.096–6.604)
0.315–0.335
(8.001–8.509)
0.035
(0.889)
MAX
SEATING
PLANE
0.500
(12.70)
MIN
0.015–0.019
(0.381–0.483)
DIA TYP
0.026–0.034
(0.661–0.864)
36°
TYP
0.029–0.045
(0.737–1.143)
0.230
(5.842)
P.C.
1
2
3
4
5
6
7
8
9
10
H10D (REV B)

**NS Package H10D**
**10-Lead TO-96 Metal Can Package (H)**

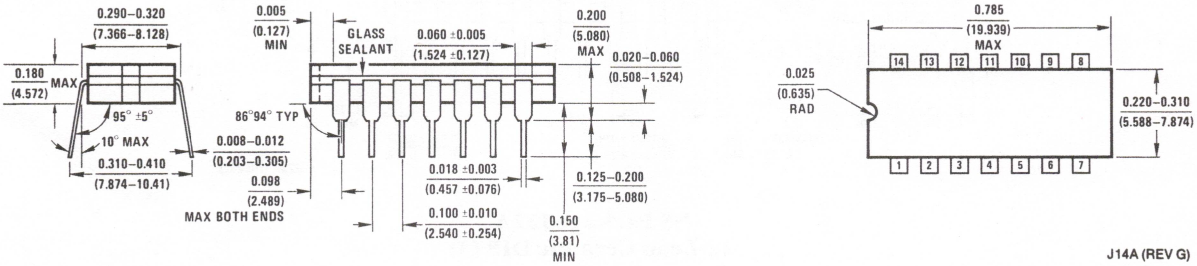
# Physical Dimensions inches (millimeters)


0.130 ± 0.005
(3.302 ± 0.127)
EPOXY SEALANT
ALL AROUND
0.065 ± 0.010
(1.651 ± 0.254)
0.030 ± 0.004
(0.762 ± 0.102)
ALUMINA SUBSTRATE
BERG LEADS
0.900 ± 0.010
(22.86 ± 0.254)
0.125
(3.175)
MIN
CERAMIC
LID
0.100 ± 0.010
(2.540 ± 0.254)
TYP
0.100
(2.540)
TYP
0.890 ± 0.009
(22.61 ± 0.229)
0.470 ± 0.005
(11.94 ± 0.127)
1
2
3
4
5
6
7
8
0.490 ± 0.005
(12.45 ± 0.127)
0.470 ± 0.005
(11.94 ± 0.127)
HY08A (REV B)

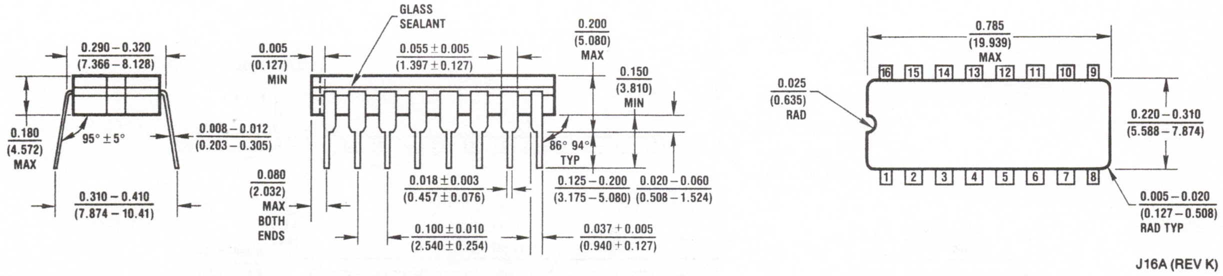
**NS Package HY08A**
**8-Lead Cavity DIP (J) (Hybrid)**


0.290–0.320
(7.366–8.128)
0.180
(4.572)
MAX
0.008–0.012
(0.203–0.305)
95° ±5°
0.310–0.410
(7.874–10.41)
0.005
(0.127)
MIN
GLASS
SEALANT
86° 94°
TYP
0.055
(1.397)
MAX
BOTH ENDS
0.030–0.070
(0.762–1.778)
0.200
(5.080)
MAX
0.150
(3.810)
MIN
0.018 ±0.003
(0.457 ±0.076)
0.125–0.200
(3.175–5.080)
0.020–0.060
(0.508–1.524)
0.100 ±0.010
(2.540 ±0.254)
0.400
(10.160)
MAX
8
7
6
5
0.310
(7.874)
MAX GLASS
0.025
(0.635)
RAD
0.220–0.291
(5.558–7.391)
1
2
3
4
0.010
(0.254)
RAD TYP
J08A (REV H)

**NS Package J08A**
**8-Lead Ceramic DIP (J)**

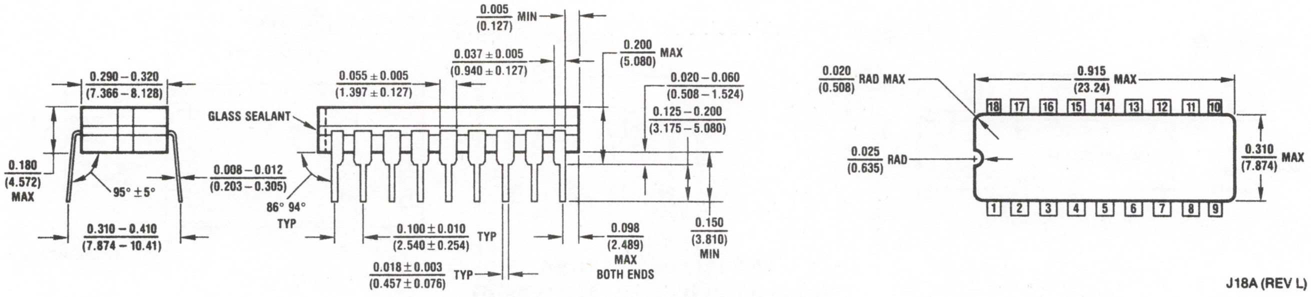

0.290–0.320
(7.366–8.128)
0.180
(4.572)
MAX
95° ±5°
10° MAX
0.310–0.410
(7.874–10.41)
0.005
(0.127)
MIN
GLASS
SEALANT
0.060 ±0.005
(1.524 ±0.127)
0.200
(5.080)
MAX
0.020–0.060
(0.508–1.524)
86°94° TYP
0.008–0.012
(0.203–0.305)
0.098
(2.489)
MAX BOTH ENDS
0.018 ±0.003
(0.457 ±0.076)
0.125–0.200
(3.175–5.080)
0.100 ±0.010
(2.540 ±0.254)
0.150
(3.81)
MIN
0.785
(19.939)
MAX
14
13
12
11
10
9
8
0.025
(0.635)
RAD
0.220–0.310
(5.588–7.874)
1
2
3
4
5
6
7
J14A (REV G)

**NS Package J14A**
**14-Lead Ceramic DIP (J)**

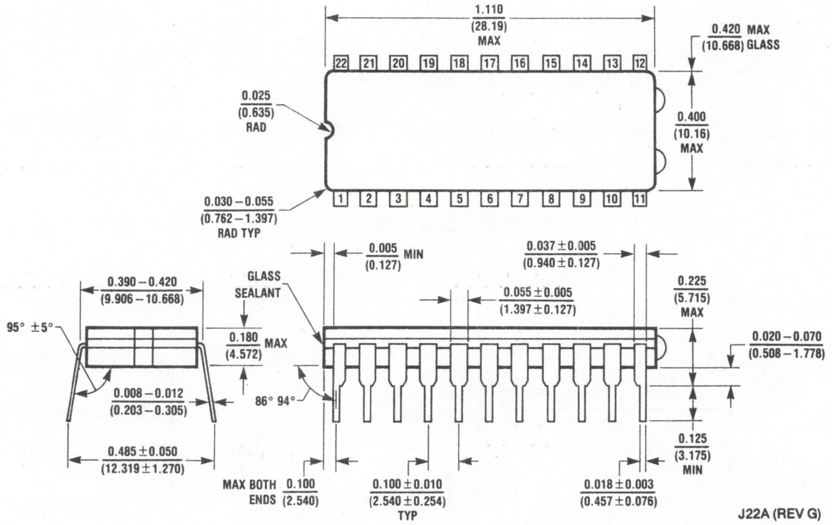

GLASS
SEALANT
0.290 – 0.320
(7.366 – 8.128)
0.180
(4.572)
MAX
95° ± 5°
0.008 – 0.012
(0.203 – 0.305)
0.310 – 0.410
(7.874 – 10.41)
0.005
(0.127)
MIN
0.055 ± 0.005
(1.397 ± 0.127)
0.200
(5.080)
MAX
0.150
(3.810)
MIN
86° 94°
TYP
0.080
(2.032)
MAX
BOTH
ENDS
0.018 ± 0.003
(0.457 ± 0.076)
0.125 – 0.200
(3.175 – 5.080)
0.020 – 0.060
(0.508 – 1.524)
0.100 ± 0.010
(2.540 ± 0.254)
0.037 + 0.005
(0.940 + 0.127)
0.785
(19.939)
MAX
16
15
14
13
12
11
10
9
0.025
(0.635)
RAD
0.220 – 0.310
(5.588 – 7.874)
1
2
3
4
5
6
7
8
0.005 – 0.020
(0.127 – 0.508)
RAD TYP
J16A (REV K)

**NS Package J16A**
**16-Lead Ceramic DIP (J)**

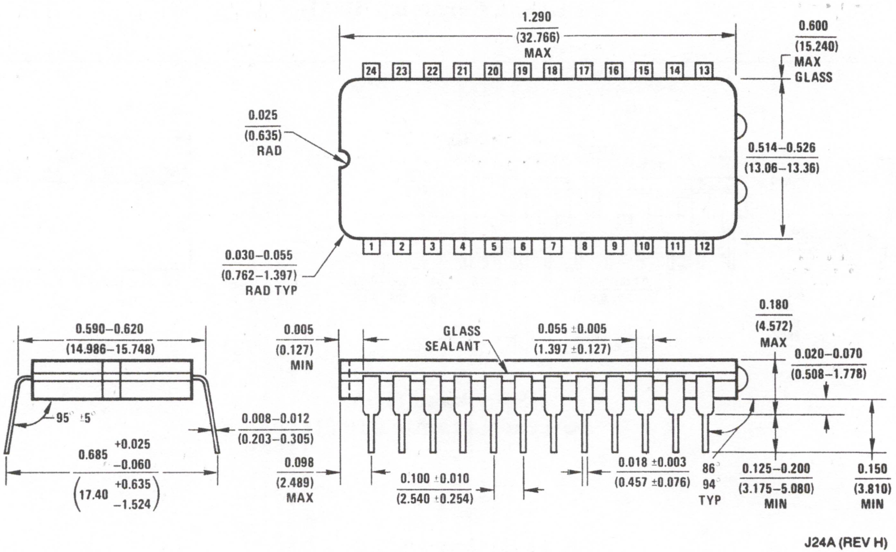
# Physical Dimensions inches (millimeters)


0.005 (0.127) MIN
0.037 ± 0.005 (0.940 ± 0.127)
0.200 (5.080) MAX
0.290 – 0.320 (7.366 – 8.128)
0.055 ± 0.005 (1.397 ± 0.127)
0.020 – 0.060 (0.508 – 1.524)
0.125 – 0.200 (3.175 – 5.080)
GLASS SEALANT
0.180 (4.572) MAX
95° ± 5°
0.008 – 0.012 (0.203 – 0.305)
86° 94° TYP
0.310 – 0.410 (7.874 – 10.41)
0.100 ± 0.010 (2.540 ± 0.254) TYP
0.098 (2.489) MAX BOTH ENDS
0.150 (3.810) MIN
0.018 ± 0.003 (0.457 ± 0.076) TYP
0.020 (0.508) RAD MAX
0.915 (23.24) MAX
18 17 16 15 14 13 12 11 10
0.025 (0.635) RAD
0.310 (7.874) MAX
1 2 3 4 5 6 7 8 9
J18A (REV L)

**NS Package J18A**
**18-Lead Ceramic DIP (J)**

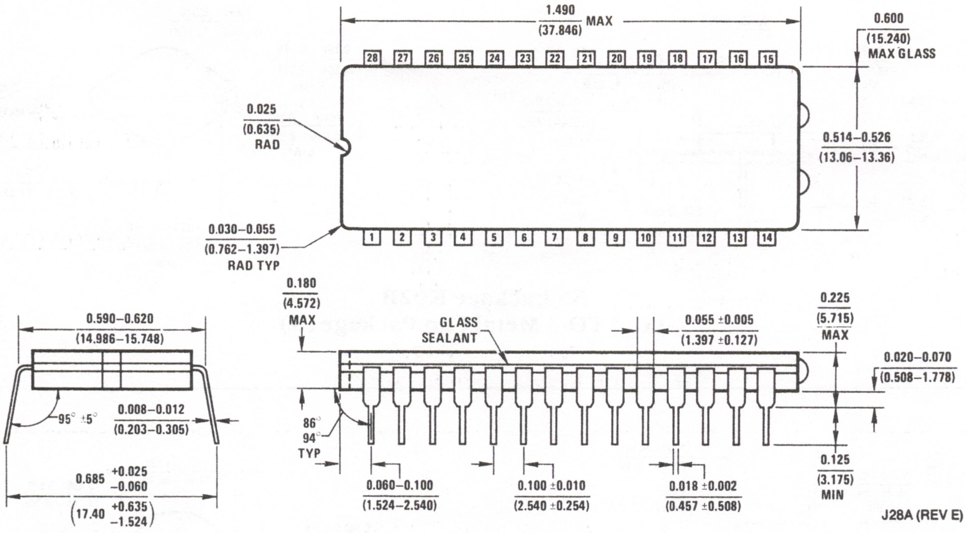

1.110 (28.19) MAX
0.420 MAX (10.668) GLASS
22 21 20 19 18 17 16 15 14 13 12
0.025 (0.635) RAD
0.400 (10.16) MAX
0.030 – 0.055 (0.762 – 1.397) RAD TYP
1 2 3 4 5 6 7 8 9 10 11
0.005 (0.127) MIN
0.037 ± 0.005 (0.940 ± 0.127)
0.390 – 0.420 (9.906 – 10.668)
GLASS SEALANT
0.055 ± 0.005 (1.397 ± 0.127)
0.225 (5.715) MAX
95° ± 5°
0.180 (4.572) MAX
0.020 – 0.070 (0.508 – 1.778)
0.008 – 0.012 (0.203 – 0.305)
86° 94°
0.125 (3.175) MIN
0.485 ± 0.050 (12.319 ± 1.270)
MAX BOTH ENDS 0.100 (2.540)
0.100 ± 0.010 (2.540 ± 0.254) TYP
0.018 ± 0.003 (0.457 ± 0.076)
J22A (REV G)

**NS Package J22A**
**22-Lead Ceramic DIP (J)**


1.290 (32.766) MAX
0.600 (15.240) MAX GLASS
24 23 22 21 20 19 18 17 16 15 14 13
0.025 (0.635) RAD
0.514–0.526 (13.06–13.36)
0.030–0.055 (0.762–1.397) RAD TYP
1 2 3 4 5 6 7 8 9 10 11 12
0.590–0.620 (14.986–15.748)
0.005 (0.127) MIN
GLASS SEALANT
0.055 ±0.005 (1.397 ±0.127)
0.180 (4.572) MAX
0.020–0.070 (0.508–1.778)
95° ±5°
0.008–0.012 (0.203–0.305)
0.685 +0.025 −0.060 (17.40 +0.635 −1.524)
0.098 (2.489) MAX
0.100 ±0.010 (2.540 ±0.254)
0.018 ±0.003 (0.457 ±0.076)
86 94 TYP
0.125–0.200 (3.175–5.080) MIN
0.150 (3.810) MIN
J24A (REV H)

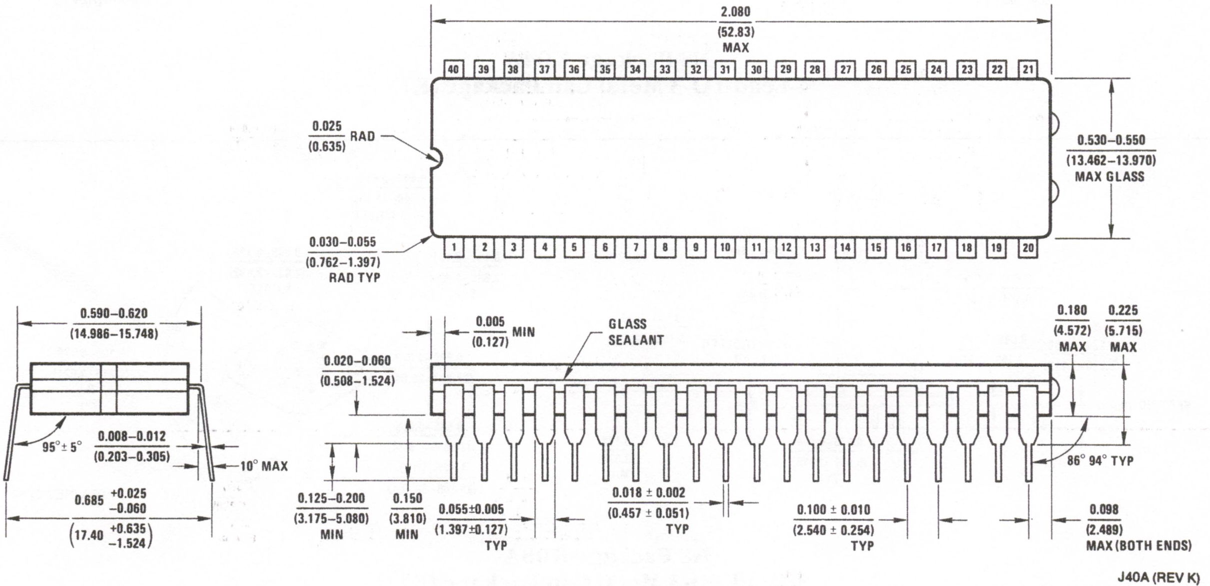
**NS Package J24A**
**24-Lead Ceramic DIP (J)**

# Physical Dimensions inches (millimeters)



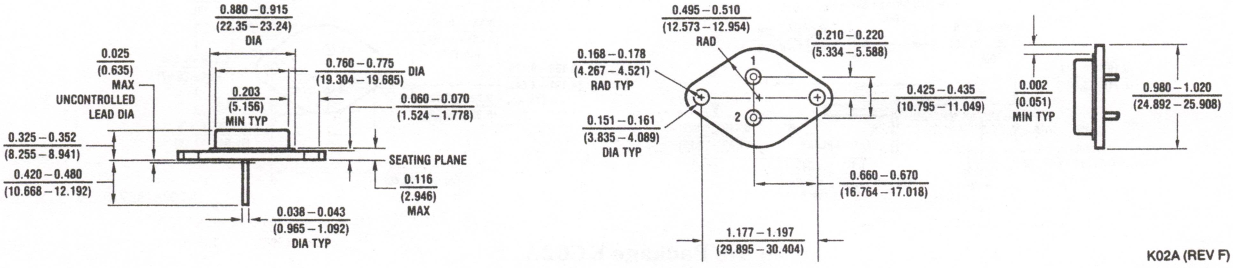
1.490 (37.846) MAX
0.600 (15.240) MAX GLASS
28 27 26 25 24 23 22 21 20 19 18 17 16 15
0.025 (0.635) RAD
0.514–0.526 (13.06–13.36)
0.030–0.055 (0.762–1.397) RAD TYP
1 2 3 4 5 6 7 8 9 10 11 12 13 14
0.180 (4.572) MAX
0.225 (5.715) MAX
0.590–0.620 (14.986–15.748)
GLASS SEALANT
0.055 ±0.005 (1.397 ±0.127)
0.020–0.070 (0.508–1.778)
95° ±5°
0.008–0.012 (0.203–0.305)
86° 94° TYP
0.125 (3.175) MIN
0.685 +0.025 −0.060
(17.40 +0.635 −1.524)
0.060–0.100 (1.524–2.540)
0.100 ±0.010 (2.540 ±0.254)
0.018 ±0.002 (0.457 ±0.508)
J28A (REV E)

**NS Package J28A**
**28-Lead Ceramic DIP (J)**



2.080 (52.83) MAX
40 39 38 37 36 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21
0.025 (0.635) RAD
0.530–0.550 (13.462–13.970) MAX GLASS
0.030–0.055 (0.762–1.397) RAD TYP
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
0.590–0.620 (14.986–15.748)
0.005 (0.127) MIN
GLASS SEALANT
0.180 (4.572) MAX
0.225 (5.715) MAX
0.020–0.060 (0.508–1.524)
95° ± 5°
0.008–0.012 (0.203–0.305)
10° MAX
86° 94° TYP
0.685 +0.025 −0.060
(17.40 +0.635 −1.524)
0.125–0.200 (3.175–5.080) MIN
0.150 (3.810) MIN
0.055±0.005 (1.397±0.127) TYP
0.018 ± 0.002 (0.457 ± 0.051) TYP
0.100 ± 0.010 (2.540 ± 0.254) TYP
0.098 (2.489) MAX (BOTH ENDS)
J40A (REV K)

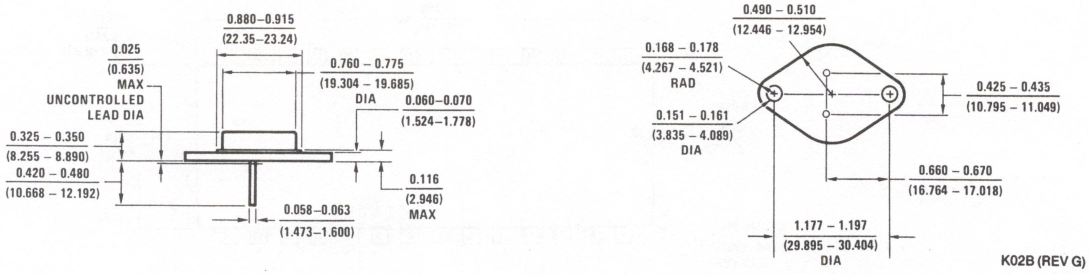
**NS Package J40A**
**40-Lead Ceramic DIP (J)**



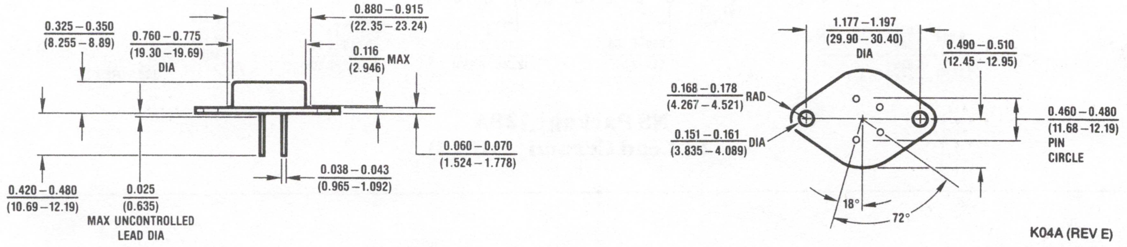
0.880 – 0.915 (22.35 – 23.24) DIA
0.025 (0.635) MAX UNCONTROLLED LEAD DIA
0.760 – 0.775 (19.304 – 19.685) DIA
0.203 (5.156) MIN TYP
0.060 – 0.070 (1.524 – 1.778)
0.325 – 0.352 (8.255 – 8.941)
SEATING PLANE
0.420 – 0.480 (10.668 – 12.192)
0.116 (2.946) MAX
0.038 – 0.043 (0.965 – 1.092) DIA TYP
0.495 – 0.510 (12.573 – 12.954) RAD
0.210 – 0.220 (5.334 – 5.588)
0.168 – 0.178 (4.267 – 4.521) RAD TYP
1
2
0.425 – 0.435 (10.795 – 11.049)
0.151 – 0.161 (3.835 – 4.089) DIA TYP
0.660 – 0.670 (16.764 – 17.018)
1.177 – 1.197 (29.895 – 30.404)
0.002 (0.051) MIN TYP
0.980 – 1.020 (24.892 – 25.908)
K02A (REV F)

**NS Package K02A**
**2-Lead TO-3 Metal Can Package (K)**
**(Steel)**

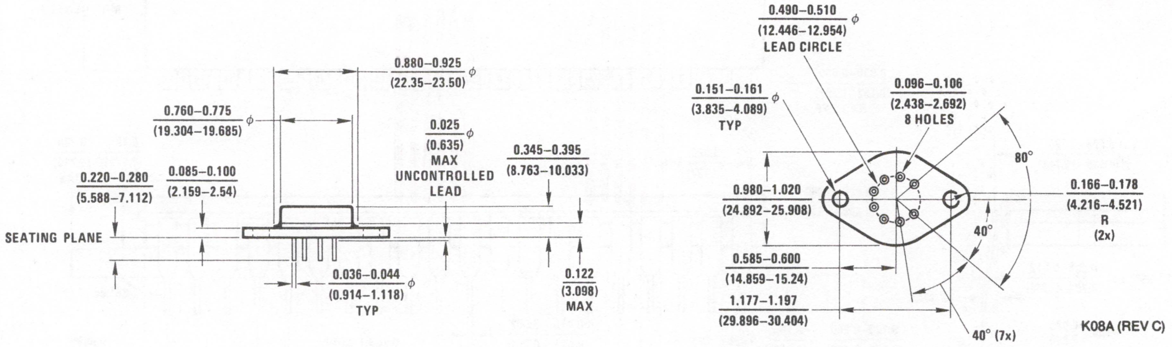
## Physical Dimensions inches (millimeters)


0.880–0.915
(22.35–23.24)
0.025
(0.635)
MAX
UNCONTROLLED
LEAD DIA
0.760 – 0.775
(19.304 – 19.685)
DIA
0.060–0.070
(1.524–1.778)
0.325 – 0.350
(8.255 – 8.890)
0.420 – 0.480
(10.668 – 12.192)
0.116
(2.946)
MAX
0.058–0.063
(1.473–1.600)
0.490 – 0.510
(12.446 – 12.954)
0.168 – 0.178
(4.267 – 4.521)
RAD
0.151 – 0.161
(3.835 – 4.089)
DIA
0.425 – 0.435
(10.795 – 11.049)
0.660 – 0.670
(16.764 – 17.018)
1.177 – 1.197
(29.895 – 30.404)
DIA
K02B (REV G)

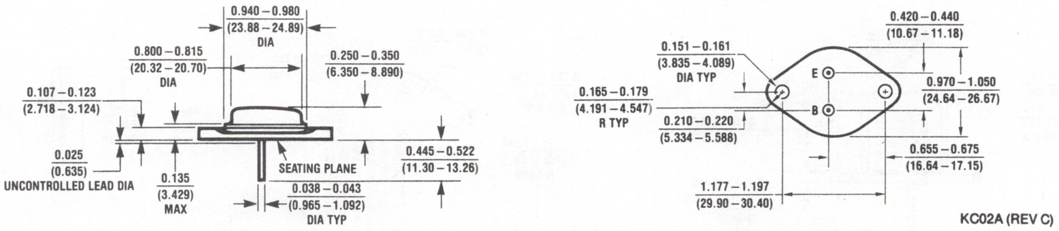
**NS Package K02B**
**2-Lead TO-3 Metal Can Package (K)**


0.325–0.350
(8.255–8.89)
0.760–0.775
(19.30–19.69)
DIA
0.880–0.915
(22.35–23.24)
0.116
(2.946)
MAX
0.060–0.070
(1.524–1.778)
0.038–0.043
(0.965–1.092)
0.420–0.480
(10.69–12.19)
0.025
(0.635)
MAX UNCONTROLLED
LEAD DIA
1.177–1.197
(29.90–30.40)
DIA
0.490–0.510
(12.45–12.95)
0.168–0.178
(4.267–4.521)
RAD
0.151–0.161
(3.835–4.089)
DIA
0.460–0.480
(11.68–12.19)
PIN
CIRCLE
18°
72°
K04A (REV E)

**NS Package K04A**
**4-Lead TO-3 Metal Can Package (K)**

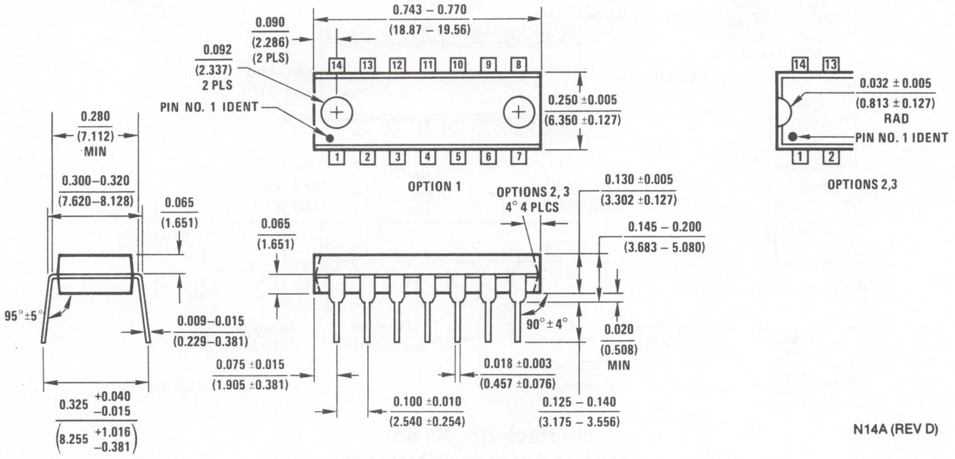

0.880–0.925
(22.35–23.50)
φ
0.760–0.775
(19.304–19.685)
φ
0.025
(0.635)
φ
MAX
UNCONTROLLED
LEAD
0.345–0.395
(8.763–10.033)
0.220–0.280
(5.588–7.112)
0.085–0.100
(2.159–2.54)
SEATING PLANE
0.036–0.044
(0.914–1.118)
φ
TYP
0.122
(3.098)
MAX
0.490–0.510
(12.446–12.954)
φ
LEAD CIRCLE
0.151–0.161
(3.835–4.089)
φ
TYP
0.096–0.106
(2.438–2.692)
8 HOLES
80°
0.980–1.020
(24.892–25.908)
0.166–0.178
(4.216–4.521)
R
(2x)
40°
0.585–0.600
(14.859–15.24)
1.177–1.197
(29.896–30.404)
40° (7x)
K08A (REV C)

**NS Package K08A**
**8-Lead TO-3 Metal Can Package (K)**

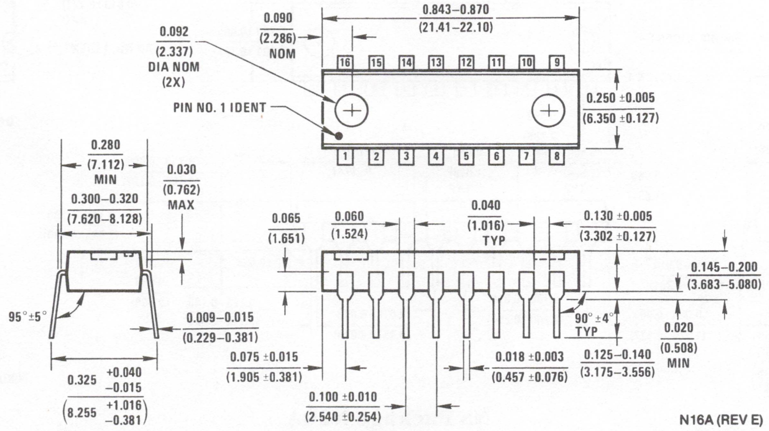

0.940–0.980
(23.88–24.89)
DIA
0.800–0.815
(20.32–20.70)
DIA
0.250–0.350
(6.350–8.890)
0.107–0.123
(2.718–3.124)
0.025
(0.635)
UNCONTROLLED LEAD DIA
0.135
(3.429)
MAX
SEATING PLANE
0.445–0.522
(11.30–13.26)
0.038–0.043
(0.965–1.092)
DIA TYP
0.420–0.440
(10.67–11.18)
0.151–0.161
(3.835–4.089)
DIA TYP
0.165–0.179
(4.191–4.547)
R TYP
E
B
0.970–1.050
(24.64–26.67)
0.210–0.220
(5.334–5.588)
0.655–0.675
(16.64–17.15)
1.177–1.197
(29.90–30.40)
KC02A (REV C)

**NS Package KC02A**
**2-Lead TO-3 Metal Can Package (KC)**
**(Aluminum)**

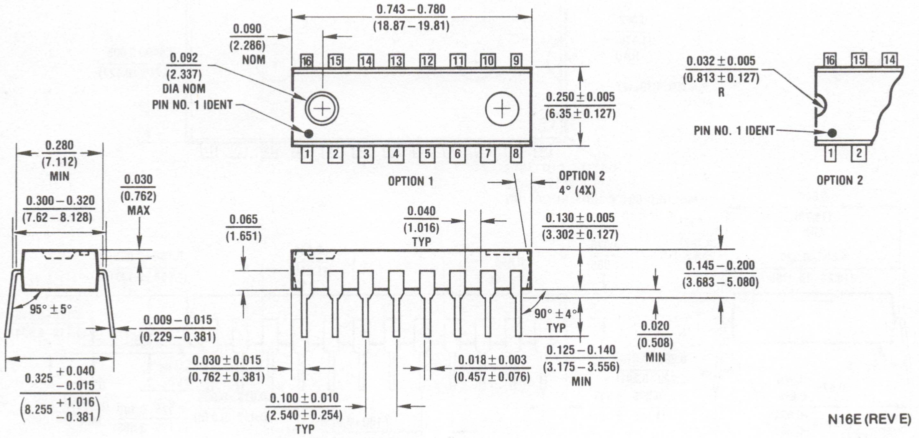
## Physical Dimensions inches (millimeters)


0.743 – 0.770
(18.87 – 19.56)
0.090
(2.286)
(2 PLS)
0.092
(2.337)
2 PLS
PIN NO. 1 IDENT
14 13 12 11 10 9 8
1 2 3 4 5 6 7
0.250 ±0.005
(6.350 ±0.127)
OPTION 1
14 13
0.032 ± 0.005
(0.813 ± 0.127)
RAD
PIN NO. 1 IDENT
1 2
OPTIONS 2,3
0.280
(7.112)
MIN
0.300–0.320
(7.620–8.128)
0.065
(1.651)
0.065
(1.651)
OPTIONS 2, 3
4° 4 PLCS
0.130 ±0.005
(3.302 ±0.127)
0.145 – 0.200
(3.683 – 5.080)
95°±5°
0.009–0.015
(0.229–0.381)
90°±4°
0.020
(0.508)
MIN
0.075 ±0.015
(1.905 ±0.381)
0.018 ±0.003
(0.457 ±0.076)
0.100 ±0.010
(2.540 ±0.254)
0.125 – 0.140
(3.175 – 3.556)
0.325 +0.040 −0.015
(8.255 +1.016 −0.381)
N14A (REV D)

**NS Package N14A**
**14-Lead Molded DIP (N)**

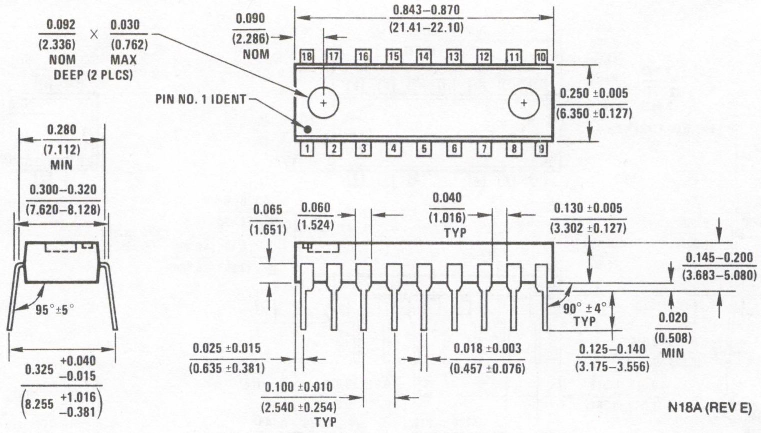

0.843–0.870
(21.41–22.10)
0.090
(2.286)
NOM
0.092
(2.337)
DIA NOM
(2X)
PIN NO. 1 IDENT
16 15 14 13 12 11 10 9
1 2 3 4 5 6 7 8
0.250 ±0.005
(6.350 ±0.127)
0.280
(7.112)
MIN
0.030
(0.762)
MAX
0.300–0.320
(7.620–8.128)
0.065
(1.651)
0.060
(1.524)
0.040
(1.016)
TYP
0.130 ±0.005
(3.302 ±0.127)
0.145–0.200
(3.683–5.080)
95°±5°
0.009–0.015
(0.229–0.381)
90°±4°
TYP
0.020
(0.508)
MIN
0.075 ±0.015
(1.905 ±0.381)
0.018 ±0.003
(0.457 ±0.076)
0.125–0.140
(3.175–3.556)
0.325 +0.040 −0.015
(8.255 +1.016 −0.381)
0.100 ±0.010
(2.540 ±0.254)
N16A (REV E)

**NS Package N16A**
**16-Lead Molded DIP (N)**

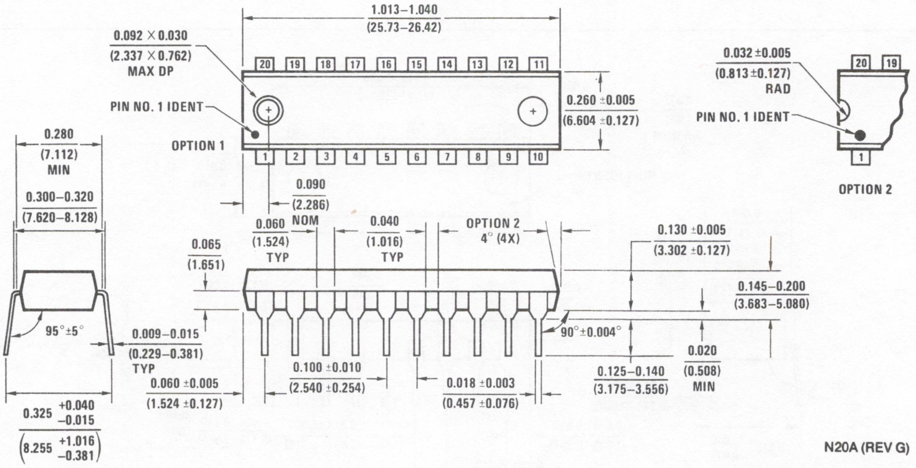

0.743 – 0.780
(18.87 – 19.81)
0.090
(2.286)
NOM
0.092
(2.337)
DIA NOM
PIN NO. 1 IDENT
16 15 14 13 12 11 10 9
1 2 3 4 5 6 7 8
0.250 ± 0.005
(6.35 ± 0.127)
OPTION 1
0.032 ± 0.005
(0.813 ± 0.127)
R
PIN NO. 1 IDENT
16 15 14
1 2
OPTION 2
0.280
(7.112)
MIN
0.030
(0.762)
MAX
0.300 – 0.320
(7.62 – 8.128)
OPTION 2
4° (4X)
0.065
(1.651)
0.040
(1.016)
TYP
0.130 ± 0.005
(3.302 ± 0.127)
0.145 – 0.200
(3.683 – 5.080)
95° ± 5°
90° ± 4°
TYP
0.020
(0.508)
MIN
0.009 – 0.015
(0.229 – 0.381)
0.125 – 0.140
(3.175 – 3.556)
MIN
0.030 ± 0.015
(0.762 ± 0.381)
0.018 ± 0.003
(0.457 ± 0.076)
0.325 +0.040 −0.015
(8.255 +1.016 −0.381)
0.100 ± 0.010
(2.540 ± 0.254)
TYP
N16E (REV E)

**NS Package N16E**
**16-Lead Molded DIP (N)**

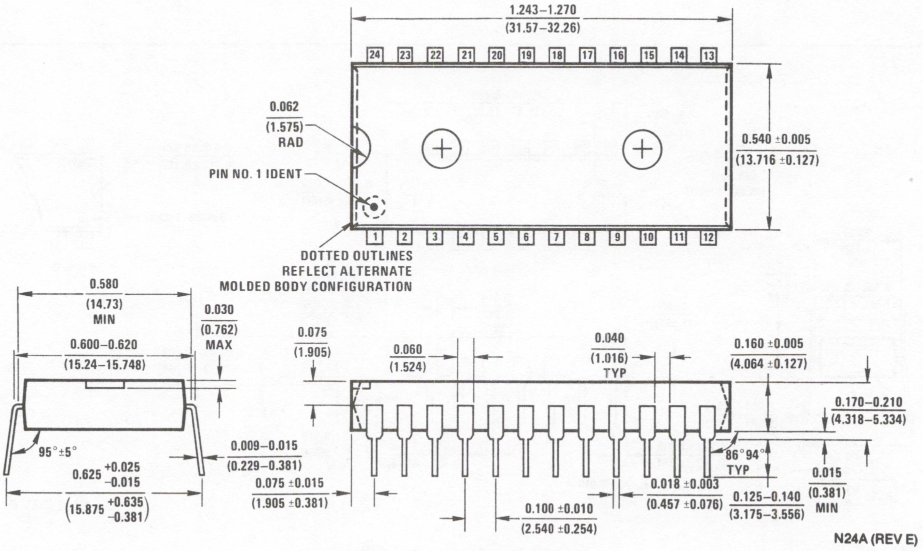
# Physical Dimensions inches (millimeters)


0.092 (2.336) NOM × 0.030 (0.762) MAX DEEP (2 PLCS)
0.090 (2.286) NOM
0.843–0.870 (21.41–22.10)
18 17 16 15 14 13 12 11 10
1 2 3 4 5 6 7 8 9
PIN NO. 1 IDENT
0.250 ±0.005 (6.350 ±0.127)
0.280 (7.112) MIN
0.300–0.320 (7.620–8.128)
95°±5°
0.325 +0.040 −0.015 (8.255 +1.016 −0.381)
0.065 (1.651)
0.060 (1.524)
0.040 (1.016) TYP
0.130 ±0.005 (3.302 ±0.127)
0.145–0.200 (3.683–5.080)
90° ±4° TYP
0.020 (0.508) MIN
0.025 ±0.015 (0.635 ±0.381)
0.018 ±0.003 (0.457 ±0.076)
0.125–0.140 (3.175–3.556)
0.100 ±0.010 (2.540 ±0.254) TYP
N18A (REV E)

**NS Package N18A**
**18-Lead Molded DIP (N)**

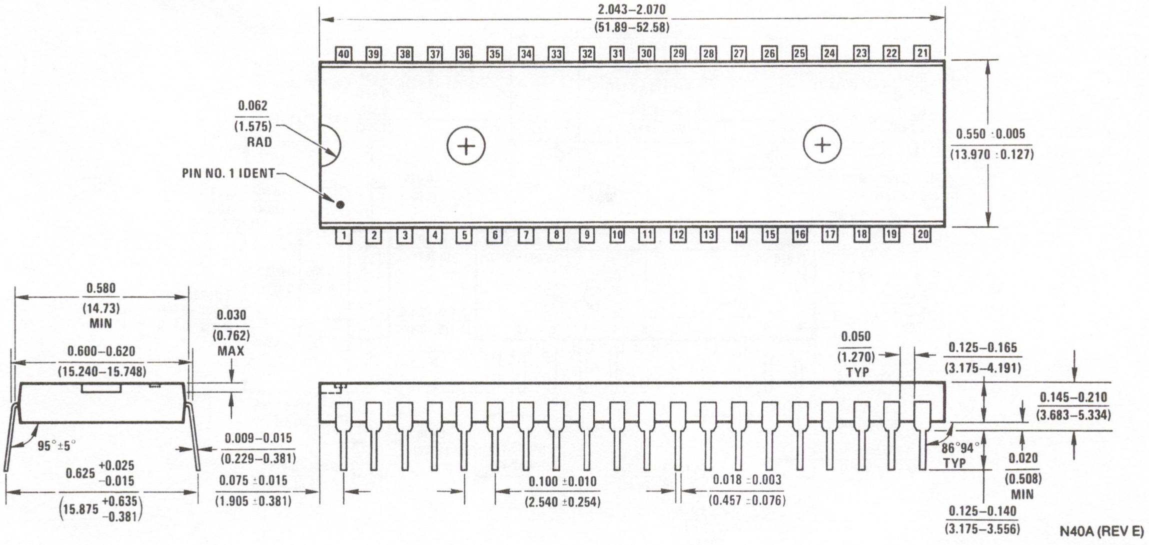

1.013–1.040 (25.73–26.42)
0.092 × 0.030 (2.337 × 0.762) MAX DP
20 19 18 17 16 15 14 13 12 11
1 2 3 4 5 6 7 8 9 10
PIN NO. 1 IDENT
OPTION 1
0.260 ±0.005 (6.604 ±0.127)
0.032 ±0.005 (0.813 ±0.127) RAD
PIN NO. 1 IDENT
OPTION 2
0.280 (7.112) MIN
0.300–0.320 (7.620–8.128)
0.090 (2.286) NOM
0.060 (1.524) TYP
0.040 (1.016) TYP
OPTION 2 4° (4X)
0.130 ±0.005 (3.302 ±0.127)
0.065 (1.651)
0.145–0.200 (3.683–5.080)
95°±5°
0.009–0.015 (0.229–0.381) TYP
90°±0.004°
0.020 (0.508) MIN
0.100 ±0.010 (2.540 ±0.254)
0.125–0.140 (3.175–3.556)
0.060 ±0.005 (1.524 ±0.127)
0.018 ±0.003 (0.457 ±0.076)
0.325 +0.040 −0.015 (8.255 +1.016 −0.381)
N20A (REV G)

**NS Package N20A**
**20-Lead Molded DIP (N)**

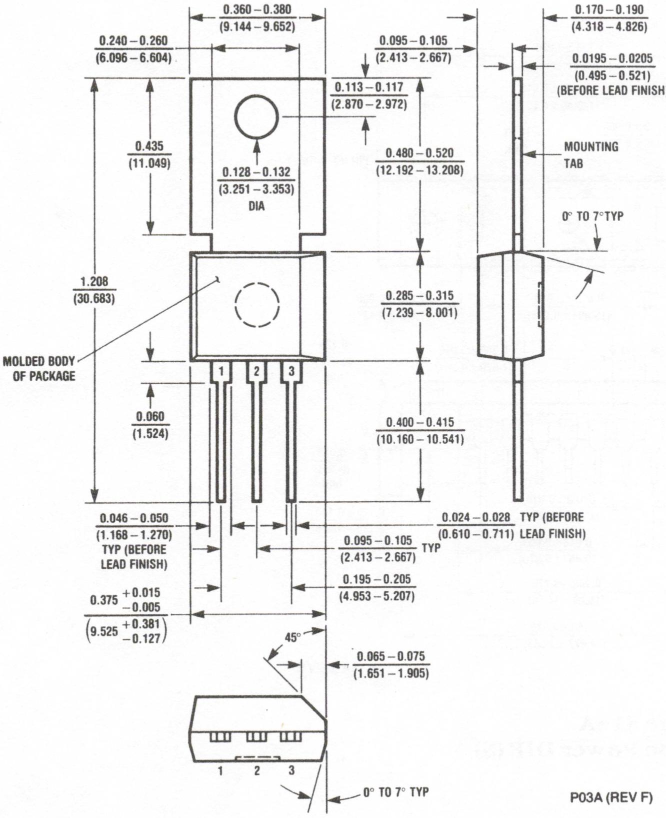

1.243–1.270 (31.57–32.26)
24 23 22 21 20 19 18 17 16 15 14 13
1 2 3 4 5 6 7 8 9 10 11 12
0.062 (1.575) RAD
PIN NO. 1 IDENT
0.540 ±0.005 (13.716 ±0.127)
DOTTED OUTLINES REFLECT ALTERNATE MOLDED BODY CONFIGURATION
0.580 (14.73) MIN
0.030 (0.762) MAX
0.600–0.620 (15.24–15.748)
0.075 (1.905)
0.060 (1.524)
0.040 (1.016) TYP
0.160 ±0.005 (4.064 ±0.127)
0.170–0.210 (4.318–5.334)
95°±5°
86°94° TYP
0.015 (0.381) MIN
0.625 +0.025 −0.015 (15.875 +0.635 −0.381)
0.009–0.015 (0.229–0.381)
0.075 ±0.015 (1.905 ±0.381)
0.018 ±0.003 (0.457 ±0.076)
0.100 ±0.010 (2.540 ±0.254)
0.125–0.140 (3.175–3.556)
N24A (REV E)

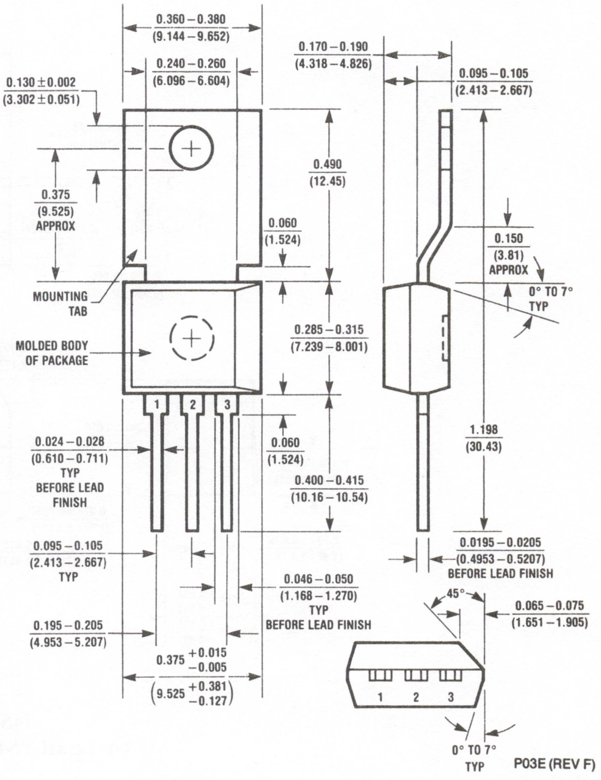
**NS Package N24A**
**24-Lead Molded DIP (N)**

## Physical Dimensions inches (millimeters)


2.043–2.070
(51.89–52.58)
40 39 38 37 36 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
0.062
(1.575)
RAD
PIN NO. 1 IDENT
0.550 ±0.005
(13.970 ±0.127)
0.580
(14.73)
MIN
0.030
(0.762)
MAX
0.600–0.620
(15.240–15.748)
95°±5°
0.625 +0.025 −0.015
(15.875 +0.635 −0.381)
0.009–0.015
(0.229–0.381)
0.075 ±0.015
(1.905 ±0.381)
0.100 ±0.010
(2.540 ±0.254)
0.018 ±0.003
(0.457 ±0.076)
0.050
(1.270)
TYP
0.125–0.165
(3.175–4.191)
0.145–0.210
(3.683–5.334)
86°94°
TYP
0.020
(0.508)
MIN
0.125–0.140
(3.175–3.556)
N40A (REV E)

**NS Package N40A**
**40-Lead Molded DIP (N)**

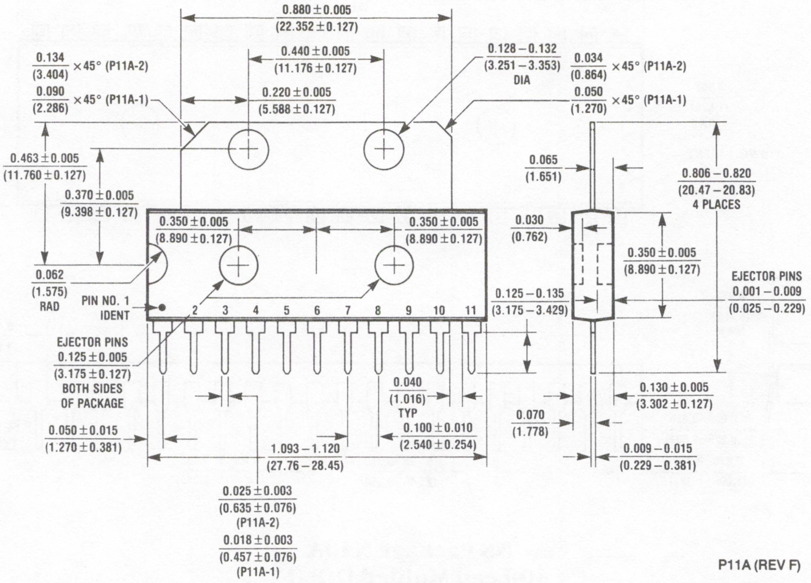

0.360–0.380
(9.144–9.652)
0.240–0.260
(6.096–6.604)
0.095–0.105
(2.413–2.667)
0.170–0.190
(4.318–4.826)
0.0195–0.0205
(0.495–0.521)
(BEFORE LEAD FINISH)
0.113–0.117
(2.870–2.972)
0.435
(11.049)
0.128–0.132
(3.251–3.353)
DIA
0.480–0.520
(12.192–13.208)
MOUNTING
TAB
0° TO 7° TYP
1.208
(30.683)
0.285–0.315
(7.239–8.001)
MOLDED BODY
OF PACKAGE
1 2 3
0.060
(1.524)
0.400–0.415
(10.160–10.541)
0.046–0.050
(1.168–1.270)
TYP (BEFORE
LEAD FINISH)
0.024–0.028 TYP (BEFORE
(0.610–0.711) LEAD FINISH)
0.095–0.105
(2.413–2.667) TYP
0.195–0.205
(4.953–5.207)
0.375 +0.015 −0.005
(9.525 +0.381 −0.127)
45°
0.065–0.075
(1.651–1.905)
1 2 3
0° TO 7° TYP
P03A (REV F)


0.360–0.380
(9.144–9.652)
0.240–0.260
(6.096–6.604)
0.170–0.190
(4.318–4.826)
0.095–0.105
(2.413–2.667)
0.130 ±0.002
(3.302 ±0.051)
0.490
(12.45)
0.375
(9.525)
APPROX
0.060
(1.524)
0.150
(3.81)
APPROX
0° TO 7°
TYP
MOUNTING
TAB
MOLDED BODY
OF PACKAGE
0.285–0.315
(7.239–8.001)
1 2 3
0.024–0.028
(0.610–0.711)
TYP
BEFORE LEAD
FINISH
0.060
(1.524)
1.198
(30.43)
0.400–0.415
(10.16–10.54)
0.0195–0.0205
(0.4953–0.5207)
BEFORE LEAD FINISH
0.095–0.105
(2.413–2.667)
TYP
0.046–0.050
(1.168–1.270)
TYP
BEFORE LEAD FINISH
45°
0.065–0.075
(1.651–1.905)
0.195–0.205
(4.953–5.207)
0.375 +0.015 −0.005
(9.525 +0.381 −0.127)
1 2 3
0° TO 7°
TYP
P03E (REV F)

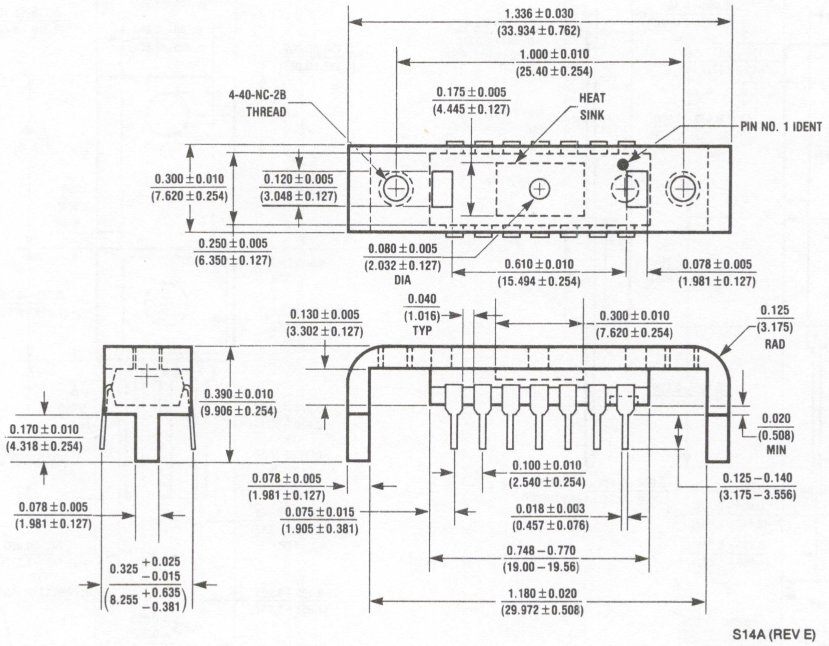
**NS Package P03A**
**3-Lead TO-202 Power Package (P)**

**NS Package P03E**
**Tab Formed 3-Lead**
**TO-202 Power Package (P)**

# **Physical Dimensions** inches (millimeters)

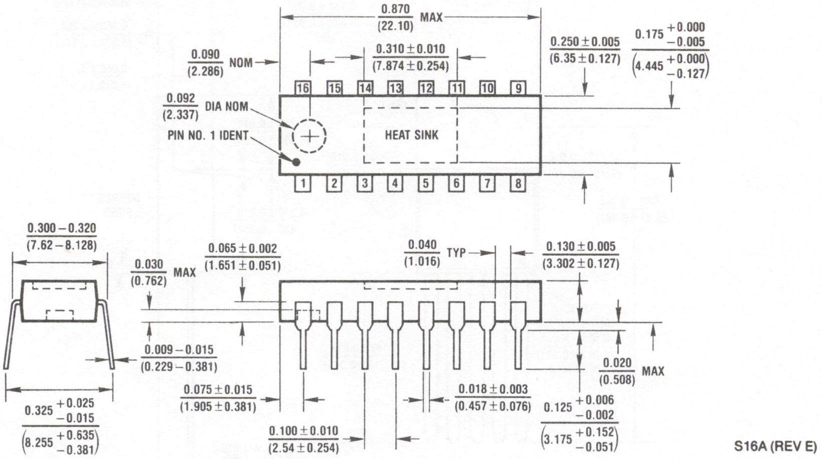

0.880 ± 0.005
(22.352 ± 0.127)
0.134
(3.404)
× 45° (P11A-2)
0.090
(2.286)
× 45° (P11A-1)
0.440 ± 0.005
(11.176 ± 0.127)
0.220 ± 0.005
(5.588 ± 0.127)
0.128 – 0.132
(3.251 – 3.353)
DIA
0.034
(0.864)
× 45° (P11A-2)
0.050
(1.270)
× 45° (P11A-1)
0.463 ± 0.005
(11.760 ± 0.127)
0.370 ± 0.005
(9.398 ± 0.127)
0.065
(1.651)
0.806 – 0.820
(20.47 – 20.83)
4 PLACES
0.350 ± 0.005
(8.890 ± 0.127)
0.350 ± 0.005
(8.890 ± 0.127)
0.030
(0.762)
0.350 ± 0.005
(8.890 ± 0.127)
EJECTOR PINS
0.001 – 0.009
(0.025 – 0.229)
0.062
(1.575)
RAD
PIN NO. 1
IDENT
2 3 4 5 6 7 8 9 10 11
0.125 – 0.135
(3.175 – 3.429)
EJECTOR PINS
0.125 ± 0.005
(3.175 ± 0.127)
BOTH SIDES
OF PACKAGE
0.040
(1.016)
TYP
0.130 ± 0.005
(3.302 ± 0.127)
0.070
(1.778)
0.100 ± 0.010
(2.540 ± 0.254)
0.050 ± 0.015
(1.270 ± 0.381)
1.093 – 1.120
(27.76 – 28.45)
0.009 – 0.015
(0.229 – 0.381)
0.025 ± 0.003
(0.635 ± 0.076)
(P11A-2)
0.018 ± 0.003
(0.457 ± 0.076)
(P11A-1)
P11A (REV F)

**NS Package P11A**
**11-Lead Single-In-Line Package (P)**

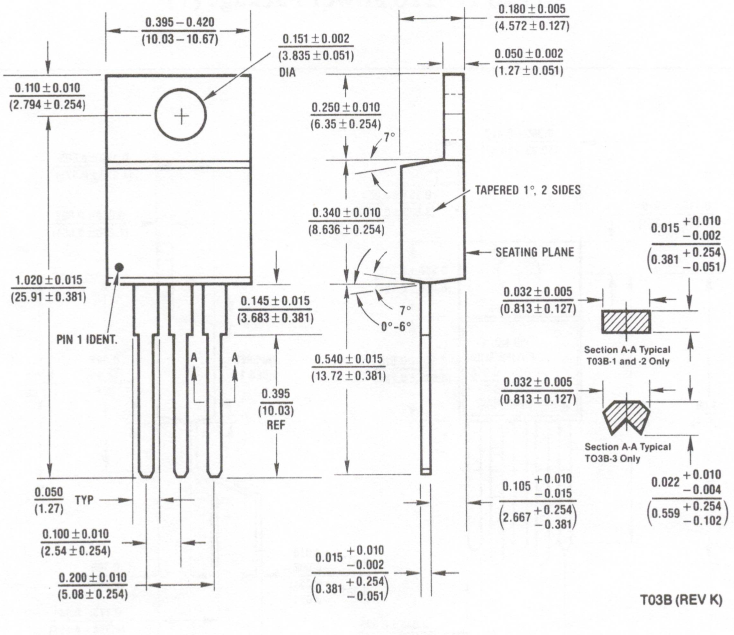

1.336 ± 0.030
(33.934 ± 0.762)
1.000 ± 0.010
(25.40 ± 0.254)
4-40-NC-2B
THREAD
0.175 ± 0.005
(4.445 ± 0.127)
HEAT
SINK
PIN NO. 1 IDENT
0.300 ± 0.010
(7.620 ± 0.254)
0.120 ± 0.005
(3.048 ± 0.127)
0.250 ± 0.005
(6.350 ± 0.127)
0.080 ± 0.005
(2.032 ± 0.127)
DIA
0.610 ± 0.010
(15.494 ± 0.254)
0.078 ± 0.005
(1.981 ± 0.127)
0.040
(1.016)
TYP
0.130 ± 0.005
(3.302 ± 0.127)
0.300 ± 0.010
(7.620 ± 0.254)
0.125
(3.175)
RAD
0.390 ± 0.010
(9.906 ± 0.254)
0.170 ± 0.010
(4.318 ± 0.254)
0.020
(0.508)
MIN
0.100 ± 0.010
(2.540 ± 0.254)
0.078 ± 0.005
(1.981 ± 0.127)
0.125 – 0.140
(3.175 – 3.556)
0.078 ± 0.005
(1.981 ± 0.127)
0.075 ± 0.015
(1.905 ± 0.381)
0.018 ± 0.003
(0.457 ± 0.076)
0.748 – 0.770
(19.00 – 19.56)
0.325 +0.025 −0.015
(8.255 +0.635 −0.381)
1.180 ± 0.020
(29.972 ± 0.508)
S14A (REV E)

**NS Package S14A**
**14-Lead "SGS" Type Power DIP (S)**

## Physical Dimensions inches (millimeters)

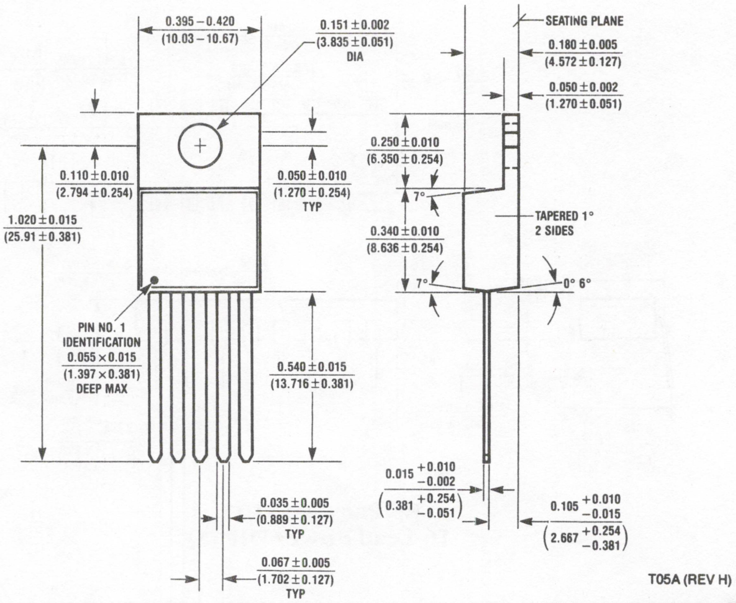

0.870 (22.10) MAX
0.310±0.010 (7.874±0.254)
0.090 (2.286) NOM
0.092 (2.337) DIA NOM
PIN NO. 1 IDENT
HEAT SINK
0.250±0.005 (6.35±0.127)
0.175 +0.000 −0.005 (4.445 +0.000 −0.127)
16 15 14 13 12 11 10 9
1 2 3 4 5 6 7 8
0.300−0.320 (7.62−8.128)
0.030 (0.762) MAX
0.065±0.002 (1.651±0.051)
0.040 (1.016) TYP
0.130±0.005 (3.302±0.127)
0.009−0.015 (0.229−0.381)
0.020 (0.508) MAX
0.075±0.015 (1.905±0.381)
0.018±0.003 (0.457±0.076)
0.125 +0.006 −0.002 (3.175 +0.152 −0.051)
0.325 +0.025 −0.015 (8.255 +0.635 −0.381)
0.100±0.010 (2.54±0.254)
S16A (REV E)

**NS Package S16A**
**16-Lead Power DIP (S)**

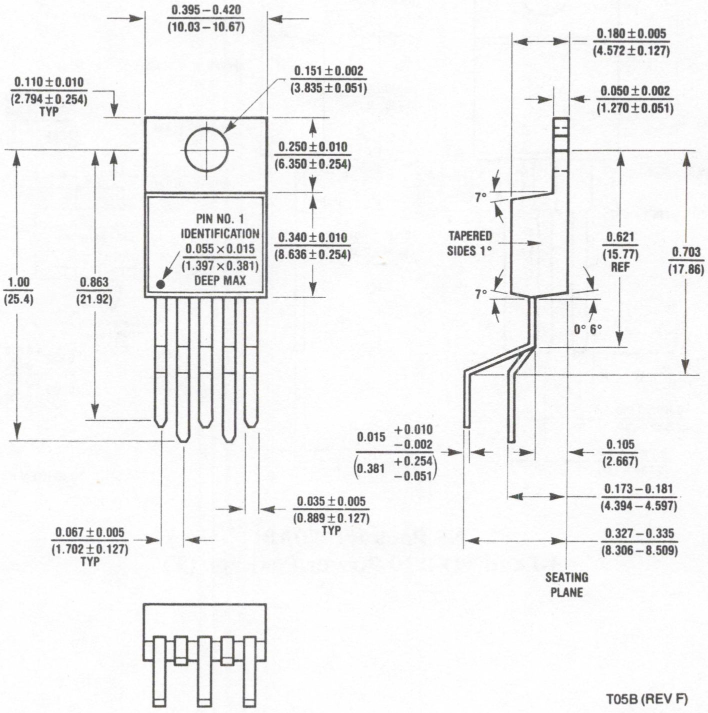

0.395−0.420 (10.03−10.67)
0.151±0.002 (3.835±0.051) DIA
0.180±0.005 (4.572±0.127)
0.050±0.002 (1.27±0.051)
0.110±0.010 (2.794±0.254)
0.250±0.010 (6.35±0.254)
7°
TAPERED 1°, 2 SIDES
0.340±0.010 (8.636±0.254)
SEATING PLANE
0.015 +0.010 −0.002 (0.381 +0.254 −0.051)
1.020±0.015 (25.91±0.381)
0.145±0.015 (3.683±0.381)
0.032±0.005 (0.813±0.127)
7°
0°−6°
PIN 1 IDENT.
A
A
0.540±0.015 (13.72±0.381)
Section A-A Typical T03B-1 and -2 Only
0.395 (10.03) REF
0.032±0.005 (0.813±0.127)
Section A-A Typical T03B-3 Only
0.105 +0.010 −0.015 (2.667 +0.254 −0.381)
0.022 +0.010 −0.004 (0.559 +0.254 −0.102)
0.050 (1.27) TYP
0.100±0.010 (2.54±0.254)
0.200±0.010 (5.08±0.254)
0.015 +0.010 −0.002 (0.381 +0.254 −0.051)
T03B (REV K)

**NS Package T03B**
**3-Lead TO-220 Power Package (T)**

## Physical Dimensions inches (millimeters)

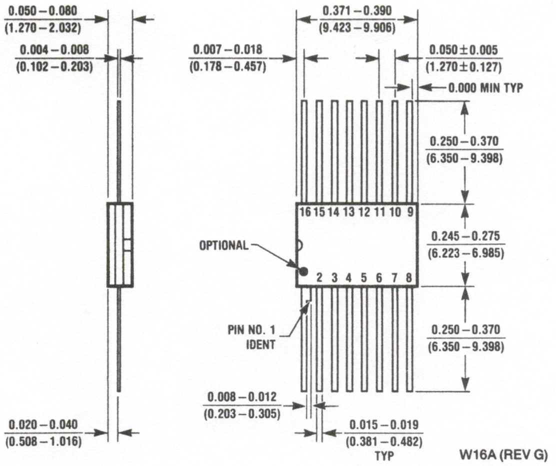

0.395 – 0.420
(10.03 – 10.67)
0.151 ± 0.002
(3.835 ± 0.051)
DIA
SEATING PLANE
0.180 ± 0.005
(4.572 ± 0.127)
0.050 ± 0.002
(1.270 ± 0.051)
0.250 ± 0.010
(6.350 ± 0.254)
0.110 ± 0.010
(2.794 ± 0.254)
0.050 ± 0.010
(1.270 ± 0.254)
TYP
7°
1.020 ± 0.015
(25.91 ± 0.381)
TAPERED 1°
2 SIDES
0.340 ± 0.010
(8.636 ± 0.254)
7°
0° 6°
PIN NO. 1
IDENTIFICATION
0.055 × 0.015
(1.397 × 0.381)
DEEP MAX
0.540 ± 0.015
(13.716 ± 0.381)
0.015 +0.010 −0.002
(0.381 +0.254 −0.051)
0.035 ± 0.005
(0.889 ± 0.127)
TYP
0.105 +0.010 −0.015
(2.667 +0.254 −0.381)
0.067 ± 0.005
(1.702 ± 0.127)
TYP
T05A (REV H)

**NS Package T05A**
**5-Lead TO-220 Power Package (T)**

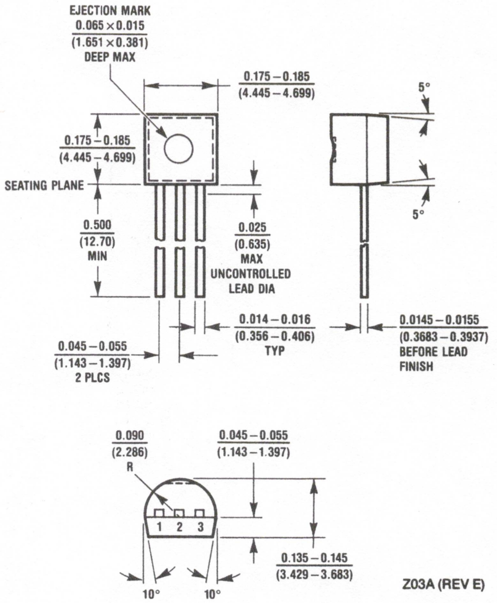

0.395 – 0.420
(10.03 – 10.67)
0.180 ± 0.005
(4.572 ± 0.127)
0.110 ± 0.010
(2.794 ± 0.254)
TYP
0.151 ± 0.002
(3.835 ± 0.051)
0.050 ± 0.002
(1.270 ± 0.051)
0.250 ± 0.010
(6.350 ± 0.254)
7°
PIN NO. 1
IDENTIFICATION
0.055 × 0.015
(1.397 × 0.381)
DEEP MAX
0.340 ± 0.010
(8.636 ± 0.254)
TAPERED
SIDES 1°
0.621
(15.77)
REF
0.703
(17.86)
1.00
(25.4)
0.863
(21.92)
7°
0° 6°
0.015 +0.010 −0.002
(0.381 +0.254 −0.051)
0.105
(2.667)
0.173 – 0.181
(4.394 – 4.597)
0.035 ± 0.005
(0.889 ± 0.127)
TYP
0.067 ± 0.005
(1.702 ± 0.127)
TYP
0.327 – 0.335
(8.306 – 8.509)
SEATING
PLANE
T05B (REV F)

**NS Package T05B**
**5-Lead TO-220 Power Package (T)**

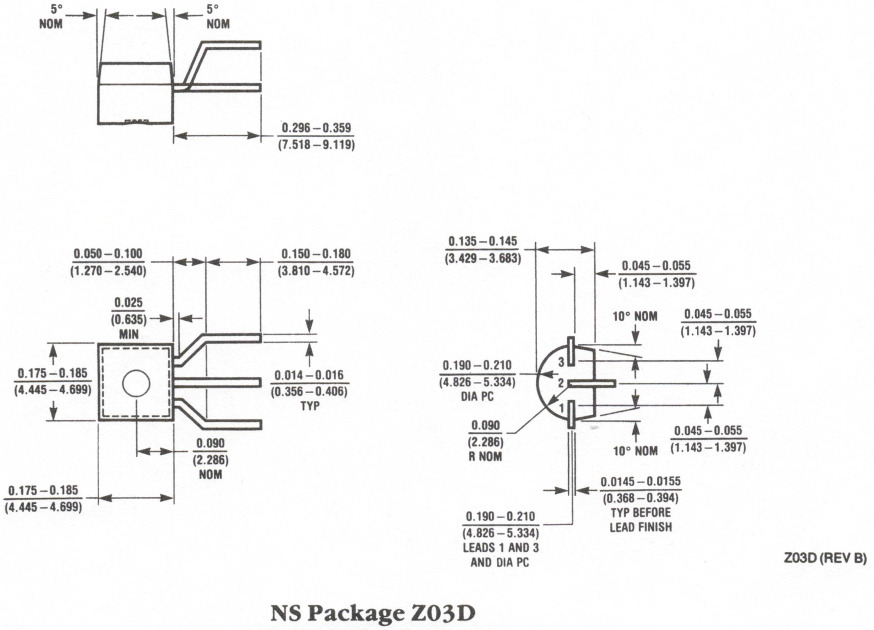
## Physical Dimensions inches (millimeters)


0.050 – 0.080
(1.270 – 2.032)
0.004 – 0.008
(0.102 – 0.203)
0.007 – 0.018
(0.178 – 0.457)
0.371 – 0.390
(9.423 – 9.906)
0.050 ± 0.005
(1.270 ± 0.127)
0.000 MIN TYP
0.250 – 0.370
(6.350 – 9.398)
16 15 14 13 12 11 10 9
OPTIONAL
0.245 – 0.275
(6.223 – 6.985)
2 3 4 5 6 7 8
PIN NO. 1
IDENT
0.250 – 0.370
(6.350 – 9.398)
0.008 – 0.012
(0.203 – 0.305)
0.020 – 0.040
(0.508 – 1.016)
0.015 – 0.019
(0.381 – 0.482)
TYP
W16A (REV G)

**NS Package W16A**
**16-Lead Ceramic Flat Package (W)**


EJECTION MARK
0.065 × 0.015
(1.651 × 0.381)
DEEP MAX
0.175 – 0.185
(4.445 – 4.699)
5°
0.175 – 0.185
(4.445 – 4.699)
SEATING PLANE
5°
0.500
(12.70)
MIN
0.025
(0.635)
MAX
UNCONTROLLED
LEAD DIA
0.014 – 0.016
(0.356 – 0.406)
TYP
0.0145 – 0.0155
(0.3683 – 0.3937)
BEFORE LEAD
FINISH
0.045 – 0.055
(1.143 – 1.397)
2 PLCS
0.090
(2.286)
R
0.045 – 0.055
(1.143 – 1.397)
1 2 3
0.135 – 0.145
(3.429 – 3.683)
10°
10°
Z03A (REV E)

**NS Package Z03A**
**3-Lead TO-92 Plastic Package (Z)**


5°
NOM
5°
NOM
0.296 – 0.359
(7.518 – 9.119)
0.050 – 0.100
(1.270 – 2.540)
0.150 – 0.180
(3.810 – 4.572)
0.025
(0.635)
MIN
0.175 – 0.185
(4.445 – 4.699)
0.014 – 0.016
(0.356 – 0.406)
TYP
0.090
(2.286)
NOM
0.175 – 0.185
(4.445 – 4.699)
0.135 – 0.145
(3.429 – 3.683)
0.045 – 0.055
(1.143 – 1.397)
10° NOM
0.045 – 0.055
(1.143 – 1.397)
0.190 – 0.210
(4.826 – 5.334)
DIA PC
3
2
1
0.090
(2.286)
R NOM
0.045 – 0.055
(1.143 – 1.397)
10° NOM
0.0145 – 0.0155
(0.368 – 0.394)
TYP BEFORE
LEAD FINISH
0.190 – 0.210
(4.826 – 5.334)
LEADS 1 AND 3
AND DIA PC
Z03D (REV B)

**NS Package Z03D**
**3-Lead TO-92 Plastic Package (Z)**

# Appendix

# Glossary of Terms

## DC Operating Conditions and Characteristics

### General Definitions

**I:** Current is the flow of electric charge from one potential to another through a conductor. The unit of measure is the Ampere, or Amp, abbreviated A. One Amp is equal to the current flowing through one ohm of resistance when one volt is applied across that resistance. Common units found in the semiconductor industry are the milliampere, abbreviated mA, equal to 0.001 A and the microampere, abbreviated $\mu$A, equal to 0.000001A. Negative current is defined as current flowing out of a device terminal and positive current is defined as current flowing into a device terminal.

**V:** Voltage, or the electromotive force which causes current to flow through a conductor. One Ampere of current flowing through one ohm of resistance develops a potential difference of one volt across that resistance. The unit of measure is the Volt, abbreviated V, and a common unit is the millivolt, abbreviated mV, equal to 0.001V.

### Input Current Parameters

**$I_I$ Maximum High Level Input Current:** Current flowing into an input when that input has the maximum voltage specified for the family applied to it. This test is used to guarantee the minimum reverse breakdown voltage of the input structure.

**$I_{IH}$ High Level Input Current:** The current flowing into an input when that input has a high level voltage equal to the minimum high level output voltage specified for the family. This test is used to check the emitter-to-emitter leakage and the inverse transistor action of a multi-emitter transistor input, the input leakage of a diode, PNP transistor, or C-B short type of input, and to guarantee the fan-in specified for the family.

**$I_{IK}$ Input Clamp Current:** The current flowing out of an input when that input is pulled below ground. This test is used to guarantee the integrity of the input clamp diode. The input clamp diode is used to limit the voltage swings on the input by clamping the negative excursions to a level equal to one diode drop below ground. This serves to reduce ringing on an incoming signal. Pulling the input below ground for an extended length of time can cause parasitic transistor action to occur between adjacent tanks on the die which can cause erroneous data to occur on the outputs of the device. To prevent this, voltages on the inputs during operation (other than high speed ringing) should be limited to no more than 0.5V below ground at all times.

**$I_{IL}$ Low Level Input Current:** The current flowing out of an input when a low level voltage equal to the maximum low level output voltage specified for the family is applied to the input. This test is used to check the input pull-up resistor on an MET or a diode input and to guarantee the specified fan-in of the family.

**$I_T+$ Current at Positive-Going Threshold Point:** The current flowing out of a transition-operated (Schmitt trigger) input when a voltage equal to the positive-going threshold voltage is applied to the input.

**$I_T-$ Current at Negative-Going Threshold Point:** The current flowing out of a transition-operated (Schmitt trigger) input when a voltage equal to the negative-going threshold voltage is applied to the input.

### Output Current Parameters

**$I_{CEX}$ Output Leakage Current:** The current flowing into an open collector output when input conditions have been applied that, according to the product specification, will cause the output to be in the logic high state. This test checks the reverse breakdown of the output transistor.

**$I_O$(off) Off-State Output Current:** The current flowing into an output with input conditions applied that, according to the product specification, will cause the output switching element to be in the off state.

NOTE: This parameter is usually specified for open collector outputs intended to drive devices other than logic circuits, such as displays. Any leakage current applied to a display may cause the display to be activated.

**$I_{OH}$ High Level Output Current:** The current flowing out of an output with input conditions applied that, according to the product specification, will establish a logic high level at the output. This test guarantees the current sourcing (drive) capability of the output and the fan-out specified for the family.

**$I_{OL}$ Low Level Output Current:** The current flowing into an output with input conditions applied that, according to the product specification, will establish a logic low level at the output. This test guarantees the current sinking capability of the output and the fan-out specified for the family.

**$I_{OS}$ Output Short-Circuit Current**: The current out of an output when that output is shorted to ground, or another specified potential, with input conditions applied that, according to the product specification, will establish a logic high level at the output.

**$I_{OZ}$ High-Impedance State Output Current**: These tests guarantee that the device will not excessively load a bus line when the device output is put into the TRI-STATE® mode.

**$I_{OZH}$ (or $I_{SINK}$)**: The current flowing into an output with input conditions applied to the output control pin such that the output is in the high impedance state and input conditions applied to the other inputs that, according to the product specification, will establish a logic low level at the output.

**$I_{OZL}$ (or $I_{SOURCE}$)**: The current flowing out of an output with input conditions applied to the output control pin such that the output is in the high impedance state and input conditions applied to the other inputs that, according to the product specification, will establish a logic high level at the output.

## Supply Current Parameters

**$I_{CCH}$ Supply Current (outputs in the high state)**: The current flowing into the $V_{CC}$ terminal of a device with input conditions applied that, according to the product specification, will establish a logic high level at the output(s).

**$I_{CCL}$ Supply Current (outputs in the low state)**: The current flowing into the $V_{CC}$ terminal of a device with input conditions applied that, according to the product specification, will establish a logic low level at the output(s).

**$I_{CCZ}$ Supply Current (outputs in the high impedance state)**: The current flowing into the $V_{CC}$ terminal of a device with input conditions applied that, according to the product specification, will establish a high impedance state at the output.

## Input Voltage Parameters

**$BV_{IN}$ Input Breakdown Voltage**: The maximum voltage that the device is guaranteed to be able to withstand without exceeding the maximum input current specification.

**$V_F$ Input Forward Voltage**: The voltage applied to the input of a device that causes the input structure to become forward biased; usually equal to the maximum output low voltage specified for the family.

**$V_{IH}$ High Level Input Voltage**: The minimum positive voltage level that can be applied to an input terminal of a device and be recognized as a logic high level.

**$V_{IK}$ Input Clamp Voltage**: The input clamp voltage specification checks the quality of the input diode whose purpose is to damp out ringing. This is not intended to be an operating condition and if this voltage is allowed to persist for any length of time, parasitic transistor action will occur between adjacent geometry tanks and circuit performance will be degraded, in some cases to the point of failure.

**$V_{IL}$ Low Level Input Voltage**: The maximum positive voltage level that can be applied to an input terminal of a device and be recognized as a logic low level.

**$V_R$ Input Reverse Voltage**: The voltage applied to an input of a device that causes the input structure to become reverse biased; usually equal to the minimum high level output voltage specified for the family.

**$V_T+$ Positive-Going Threshold Voltage**: The voltage level at a transition-operated (Schmitt trigger) input that causes operation of the logic element according to specification as the input voltage rises from a level below the negative-going threshold voltage $V_T-$.

**$V_T-$ Negative-Going Threshold Voltage**: The voltage level at a transition-operated (Schmitt trigger) input that causes operation of the logic element according to specification as the input voltage falls from a level above the positive-going threshold voltage, $V_T+$.

## Output Voltage Parameters

**$V_{OH}$ High Level Output Voltage**: The voltage at an output terminal with input conditions applied that, according to the product specification, will establish a high level at the output.

**$V_{OL}$ Low Level Output Voltage**: The voltage at an output terminal with input conditions applied that, according to the product specification, will establish a low level at the output.

**$V_O$(off) Off-State Output Voltage**: The voltage at an output terminal with input conditions applied that, according to the product specification, will cause the output switching element to be in the off state.

NOTE: This characteristic is usually specified only for outputs without internal pull-up elements intended for driving devices other than logic circuits.

**$V_O$(on) On-State Output Voltage**: The voltage at an output terminal with input conditions applied that, according to the product specification, will cause the output switching element to be in the on state.

NOTE: This characteristic is usually specified only for outputs without internal pull-up elements intended for driving devices other than logic circuits.

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Section 2

# 1987 Selection Guide for Fairchild Products

Application Specific ICs
Interface
Linear
Logic
Memory
Microprocessors
Power & Discrete
Programmable Logic
Telecommunications
Aerospace & Defense
Packaging and Order Information
Index

## TRADEMARKS

### Fairchild Semiconductor Corporation

ASPECT™
CLASIC™
FACT™
FAIRCAD™
Fairtech™
FAST®
I$^3$L®
ISOPLANAR™
ISOPLANAR-Z™
PLANAR™
POWERplanar™

# Application Specific ICs

For additional Application Specific IC products, see pages 19 and 419.

# Application Specific ICs (ASIC)

Fairchild's ASIC product line includes the ECL and CMOS high-performance gate array families. In addition, extensive customer support facilities include the unique capabilities of the FAIRCAD™ design system, full-service FAIRTECH design centers, and the industry's first combination of an on-site Cray supercomputer and E-Beam Direct-Write-On-Silicon system to speed turn-around. To meet aerospace and defense applications, both CMOS and ECL gate arays are total dose radiation-hardened to $10^6$ Rads (Si).

## ECL

The FGE Series ECL gate arrays range from 100 to 6,300 gates. Features include 600 MHz performance, ECL 100K and ECL 10K compatibility, user-selectable speed/power performance options, and TTL/ECL I/O choices with the FGE2500 and 2K RAM on the FGE6320R.

The FGA Series is a new family of ECL gate arrays, based on the ASPECT process, ranging from 600 to 15,000 gates. The arrays have speed and power options with propagation delays of 120 ps but using only 30 % of the conventional ECL power.

## CMOS

**FGC Series:** The FGC Series of CMOS gate arrays provides densities from 500 to 8,000 gates, on-chip test, operating frequencies as high as 70 MHz, and CMOS- or TTL-selectable I/Os.

**FACTCELL FSB/FSH Series:** The FACTCELL Series is an advanced CMOS cell-based family that provides high-density, high-performance solutions for digital logic system designers. The system uses the traditional standard cell design methodology together with the newer silicon compiler techniques to produce customized VLSI designs.

Both the ECL and CMOS families are available in a wide variety of voltage and temperature specifications and advanced packaging configurations.

## FAIRCAD

Fairchild's fully integrated, technology-independent gate array design software supports all design tasks from design capture through final design database creation for prototype manufacturing. And FAIRCAD is available on tape for installation on your VAX™ VMS™ system including the MicroVAX™ II. A proven tool for designing circuitry using our CMOS and ECL gate arrays, FAIRCAD combines engineering graphics with powerful programs to compile, analyze, simulate, and place and route your design. FAIRCAD is menu-driven with extensive on-line help listings and a built-in system monitor that ensure the proper program sequence.

This combination of high-density, multiple technology, fully integrated computer-aided design, and advanced computer hardware provide the industry's most comprehensive choice of speed, power, cost, volume, and turnaround time.

# ECL Gate Arrays

## FGE Series

| | | | | Typical Buffer Delay | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Device | Gate Equivalent | I/O Levels | Typical Internal Gate Delay (ns) | Input (ns) | Output (ns) | Typical Power (W) | Max. I/O | Package Codes | Availability |
| FGE0050 | 100 | 100K/10K ECL | 0.225–0.57 | 0.0 | 0.45 | 0.1–0.4 | 21 | 24 FPK<br>24 CDIP | Now |
| FGE0500 | 680 | 100K/10K ECL | 0.225–0.57 | 0.0 | 0.45 | 1.5–4.0 | 72 | 40 CDIP<br>44 LCC<br>84 LDCC<br>84 CPGA | Now |
| FGE2000 | 2500 | 100K/10K ECL | 0.225–0.57 | 0.0 | 0.45 | 3.0–8.0 | 120 | 132 LDCC<br>132 CPGA | Now |
| FGE2500 | 2840 | ECL/TTL Mix | 0.225–0.57 | 0.0 | 0.45 | 3.0–8.0 | 120 | 156 CPGA | Now |
| FGE6300 | 6300 | 100K/10K ECL | 0.250–0.62 | 0.0 | 0.45 | 4.5–10 | 220 | 301 CPGA | Now |
| FGE6320R | 3500/ 2304 RAM | 100K/10K ECL | 0.250–0.62 | 0.0 | 0.45 | 4.5–10 | 220 | 301 CPGA | Now |

## FGA Series

| | | | | Typical Buffer Delay | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Device | Gate Equivalent | I/O Levels | Typical Internal Gate Delay (ns) | Input (ns) | Output (ns) | Typical Power (W) | Max. I/O | Package Codes | Availability |
| FGA14000 | 15,400 | 10K/100K ECL | 0.120–0.20 | 0.0 | 0.45 | 10–20 | 256 | 323 CPGA | Now |
| FGA14040R | 7,390/ 4,600 RAM | 10K/100K ECL | 0.120-0.20 | 0.0 | 0.45 | 10-20 | 256 | 323 CPGA | 2Q88 |
| FGA8000 | 8,050 | 10K/100K TTL/ECL | 0.120-0.20 | 0.0 | 0.45 | 6-12 | 220 | 301 CPGA | 3Q88 |
| FGA4000 | 4,070 | 10K/100K TTL/ECL | 0.120-0.20 | 0.0 | 0.45 | 3-6 | 128 | 172 CPGA | 1Q88 |
| FGA1300 | 1,445 | 10K/100K TTL/ECL | 0.120-0.20 | 0.0 | 0.45 | 1-3 | 72 | 108 CPGA | 1Q88 |
| FGA600 | 605 | 10K/100K TTL/ECL | 0.120-0.20 | 0.0 | 0.45 | 0.5-1.5 | 32 | 44 LDCC | 3Q88 |

# CMOS Gate Arrays

## FGC Series

|  |  |  |  | Typical Buffer Delay |  |  |  |
|---|---|---|---|---|---|---|---|
| Device | Gate Equivalent | I/O Levels | Typical Internal Gate Delay (ns) | Input (ns) | Output (ns) | Max. I/O | Package Codes |
| FGC0500 | 540 | TTL/CMOS | 1.1 | 2.1 | 2.3 | 40 | PDIP, CDIP, PLCC, CLCC |
| FGC1200 | 1188 | TTL/CMOS | 1.1 | 2.0 | 3.8 | 73 | PDIP, CDIP, PLCC, CLCC, CPGA |
| FGC2400 | 2625 | TTL/CMOS | 1.1 | 2.0 | 3.8 | 109 | PDIP, CDIP, PLCC, CLCC, CPGA |
| FGC4000 | 3960 | TTL/CMOS | 1.1 | 2.0 | 3.8 | 133 | PLCC, CLCC, CPGA |
| FGC6000 | 6000 | TTL/CMOS | 1.1 | 2.0 | 3.8 | 161 | PLCC, CLCC, CPGA |
| FGC8000 | 7896 | TTL/CMOS | 1.1 | 2.0 | 3.8 | 181 | PLCC, CLCC, CPGA |

## FACTCELL FSC Series—CMOS Standard Cells

|  |  |  |  | Typical Buffer Delay |  |  |
|---|---|---|---|---|---|---|
| Device | Gate Equivalent | I/O Levels | Typical Internal Gate Delay (ns) | Input (ns) | Output (ns) | Max. I/O (Approx.) |
| FSC0500 | to 500 | TTL/CMOS | 0.9 | 1.7 | 3.1 | 68 |
| FSC1000 | to 1000 | TTL/CMOS | 0.9 | 1.7 | 3.1 | 84 |
| FSC2000 | to 2000 | TTL/CMOS | 0.9 | 1.7 | 3.1 | 107 |
| FSC3000 | to 3000 | TTL/CMOS | 0.9 | 1.7 | 3.1 | 124 |
| FSC4000 | to 4000 | TTL/CMOS | 0.9 | 1.7 | 3.1 | 140 |
| FSC5000 | to 5000 | TTL/CMOS | 0.9 | 1.7 | 3.1 | 153 |
| FSC6000 | to 6000 | TTL/CMOS | 0.9 | 1.7 | 3.1 | 165 |
| FSC7000 | to 7000 | TTL/CMOS | 0.9 | 1.7 | 3.1 | 176 |
| FSC8000 | to 8000 | TTL/CMOS | 0.9 | 1.7 | 3.1 | 186 |
| FSC9000 | to 9000 | TTL/CMOS | 0.9 | 1.7 | 3.1 | 195 |
| FSC10K | to 10K | TTL/CMOS | 0.9 | 1.7 | 3.1 | 204 |
| FSC11K | to 11K | TTL/CMOS | 0.9 | 1.7 | 3.1 | 213 |
| FSC12K | to 12K | TTL/CMOS | 0.9 | 1.7 | 3.1 | 221 |
| FSC13K | to 13K | TTL/CMOS | 0.9 | 1.7 | 3.1 | 229 |
| FSC14K | to 14K | TTL/CMOS | 0.9 | 1.7 | 3.1 | 237 |
| FSC15K | to 15K | TTL/CMOS | 0.9 | 1.7 | 3.1 | 244 |
| FSC16K | to 16K | TTL/CMOS | 0.9 | 1.7 | 3.1 | 251 |
| FSC17K | to 17K | TTL/CMOS | 0.9 | 1.7 | 3.1 | 258 |
| FSC18K | to 18K | TTL/CMOS | 0.9 | 1.7 | 3.1 | 265 |
| FSC19K | to 19K | TTL/CMOS | 0.9 | 1.7 | 3.1 | 271 |
| FSC20K | to 20K | TTL/CMOS | 0.9 | 1.7 | 3.1 | 277 |

# FAIRCAD

## FAIRCAD Features

- Interactive Design Capture
- Design Rule Checking
- Interactive Logic and Timing Simulation
- Controllability Fault Analysis
- Auto/Interactive Placement and Routing
- Test Vector Formatting for ATE

## FAIRCAD Design Advantages

FAIRCAD is a proven tool for designing circuitry using CMOS and ECL gate arrays. It combines engineering graphics with powerful programs to compile, analyze, simulate, and place and route designs. Proper program sequence is assured through the use of menu-driven programs with on-line help listings and a built-in system monitor.

Fairchild's fully integrated, technology-independent gate array design software supports all design tasks, from design capture through final design database creation for prototype manufacturing.

Fault simulation on FAIRCAD is simplified through the use of our Cray 1-S Supercomputer, which processes simulations as much as 50 times faster than on other devices. Remote communication links to the Cray make designing at customer facilities even more convenient. In addition, turnaround times at Fairchild are further reduced by an in-house Cambridge E-Beam Direct-Write-On-Silicon system. FAIRCAD is also available on tape for installation on a VAX VMS system, including the MicroVAX II.

## Engineering Support

Fairchild applications engineers, the experts of gate array design, are available for assistance and, by arrangement, can complete some or all of FAIRCAD's design tasks for the customer.

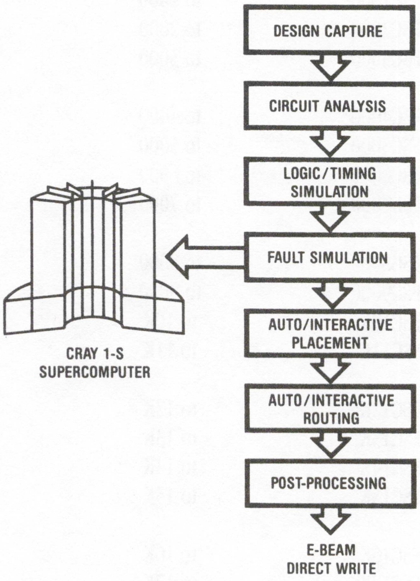
## Customer Instruction

Fairchild offers complete instruction to assist customers in developing circuit concepts. Courses are taught by knowledgeable applications engineers at FAIRTECH Design Centers and, by special arrangement, at customer facilities. Classrooms equipped with color graphics terminals (one per student) and video projection systems provide a unique opportunity to explore gate array design.

First-time customers take both the hardware design course (1–2 days) for the chosen gate array family and the FAIRCAD training course (5 days). Since FAIRCAD processes designs independent of technology, the course need not be repeated to accomplish a design using a different Fairchild gate array family.

Instruction on FAIRCAD system installation and administration is also available. A complete listing of class dates and times is available at FAIRTECH Design Centers and sales offices.

**Typical FAIRCAD Design Flow**



# Fairchild Technology Centers

## FAIRTECH Centers

FAIRTECH Centers are state-of-the-art technology and design environments that provide the tools, service, and support you need to turn ideas into products. All Fairchild Semiconductor products, including programmable logic, semicustom (bipolar and CMOS gate arrays, and CMOS standard cells), LSI controllers, modems, microprocessors and microcontrollers, are supported by the FAIRTECH Centers.

These Centers are the most up-to-date facilities of their kind in the world, and offer convenient locations in Burlington, Massachusetts; Bloomington, Minnesota; Richardson, Texas; and Tustin and Santa Clara, California.

## The Right Tools for the Job

The time needed to implement your complex product and system designs decreases significantly as you gain ready access to training and design tools. Each Center is fully equipped with FAIRCAD computer-aided design stations for gate array and standard cell—interactive systems that permit the designer to perform graphical schematic capture; logic, timing, and fault simulation; placement and routing; as well as post-layout timing verification. Workstations are linked via communications lines to a DEC® VAX 11/780 system and a CRAY I, which also enables design entry from your local facility.

Applications labs at the Center will help you evaluate the designs. These comprehensive resources include memory and logic programmers, logic analyzers, oscilloscopes, and hardware prototyping tools.

The Fairtech Centers serve as a gateway to all of Fairchild's products and capabilities, as well as a resource for design assistance. The unique combinations of products and services offer cost-effective solutions to system development requirements:

- Semicustom products—ECL and CMOS gate arrays and CMOS standard cells.
- Programmable products—PROMs and FASTPLAs programmable logic devices.
- High-performance microprocessor products.
- Digital logic products—CMOS LSI, FAST LSI, and ECL.
- Memories—SRAMs, FIFO, register files, and controllers, in CMOS and bipolar technologies.
- Computer peripheral controllers—Winchester disk circuits.
- Telecommunications circuits—COMBOs and modems.
- Analog devices—interface circuits, power MOS, voltage regulators, transistors, and diodes.

## Services that Make a Difference

Each FAIRTECH Center is staffed by Technical Product Specialists who offer in-depth knowledge of specific product lines and Fairtech Applications Engineers who provide design support directly at your site. By providing fast and effective local support, we reduce your time to market and minimize your cost of ownership of Fairchild's products.

## Support that Follows the Design

FAIRTECH Centers exist to support your design needs—and will do whatever it takes to get the job done right. Fairchild's extensive customer communication network provides valuable feedback on such areas as software design tools, packaging, circuit testability, and other requirements for cost-effective system design. And each Center is equipped with a technical inquiry telephone line that represents immediate information, assistance, or answers to you.

The idea behind this comprehensive support program is to help you turn out a truly superior product. And FAIRTECH Centers are the shortest distance between your idea and the marketplace.

### Boston Office

111 South Bedford Street, Suite 200
Burlington, MA 01803
Phone (617) 273-7430

### Tustin Office

15641 Red Hill Avenue, Suite 120
Tustin, CA 92680
Phone (714) 259-1540

### Santa Clara Office

2900 Semiconductor Drive
Santa Clara, CA 95051
Phone (408) 721-6247

### Dallas Office

1702 North Collins Boulevard, Suite 101
Richardson, TX 75081
Phone (214) 234-3811
Technical Inquiries—(214) 234-3811

### Minneapolis Office

1801 East 79th Street, Suite 1
Bloomington, MN 55420
Phone (612) 854-8200

# Interface

For additional Interface products, see page 35.

# Interface

Fairchild offers a comprehensive line of compatible drivers, receivers, transceivers, and repeaters meeting EIA RS-485 and RS-422 specifications. These circuits offer such special features as thermal shutdown protection, 3-state outputs, and monotonic output switching.

In addition, Fairchild offers an enhanced version that incorporates our new state-of-the-art L FAST bipolar technology. The L FAST technology allows for higher speeds and lower currents by utilizing extremely short gate delay times. Thus, L FAST allows the offering of lower power, extended temperature range, and improved specifications.

The RS-485 designs can include multipoint or party-line buses of as many as 32 driver/receiver pairs, handling transmissions of up to 15 Mb/sec at 40-foot bus lengths.

Upgrading RS-422-based systems is simplified by using the RS-485 family, whose data rate capabilities match the fastest RS-422, and provide a compatible interface between the two systems.

## Interface Products Cross-Reference Guide

| Fairchild | Motorola | National | TI | SG | Signetics |
|---|---|---|---|---|---|
| **Dual Line Drivers and Receivers** | | | | | |
| μA9614 | | DS75114 | | | |
| μA9615 | | DS75115 | SN75115 | | |
| μA9636A | MC3488A | | uA9636A | | |
| μA9637A | | | uA9637A | | |
| μA9638 | | | uA9638 | | |
| μA9639A | | | uA9639A | | |
| μA9643 | | | | | |
| μA55107A | | | | | |
| μA75107A | MC75107 | DS75107 | SN75107A | | |
| μA75107B | | | SN75107B | | |
| μA75108B | MC75108 | DS75108 | SN75108B | | |
| μA55110A | | | | | |
| μA75110A | MC75110 | | SN75110A | | |
| μA75150 | | DS75150 | SN75150 | | |
| **Quad Line Drivers and Receivers** | | | | | |
| μA1488 | MC1488 | DS1488 | SN75188,<br>MC1488 | | MC1488 |
| μA1489 | MC1489 | DS1489 | SN75189 | | |
| μA1489A | MC1489A | DS1489A | MC1489 | SG1489A | MC1489A |
| μA26LS31 | AM26LS31 | DS26LS31 | AM26LS31 | | AM26LS31 |
| μA26LS32 | AM26LS32 | DS26LS32 | AM26LS32 | | |
| μA3486 | MC3486 | DS3486 | MC3486 | | |
| μA3487 | MC3487 | DS3487 | MC3487 | | |
| μA9645 | | | | | |
| μA9665 | MC1411 | LM2001 | ULN2001 | SG2001 | |
| μA9666 | TDA2002 | LM2002,<br>TDA2002 | ULN2002A | SG2002 | |
| μA9667 | MC1413 | TDA2003 | ULN2003A | SG2003 | |
| μA9668 | MC1416 | | ULN2004A | SG2004 | ULN2004 |
| μA75154 | | DS75154 | SN75154 | SG75154 | |
| μA75491 | MC75491 | DS75491 | SN75491 | | |
| μA75492 | MC75492 | DS75492 | SN75492 | | |
| μA96172 | | | SN75172 | | |
| μA96173 | | | SN75173 | | |
| μA96174 | | | SN75174 | | |
| μA96175 | | | SN75175 | | |

## Interface Products Cross-Reference Guide (Continued)

| Fairchild | Motorola | National | TI | SG | Signetics |
|---|---|---|---|---|---|
| **Peripheral Drivers** | | | | | |
| μA75450 | | DS75450 | SN75450 | | |
| μA75451A | | DS75451 | SN75451 | | |
| μA75451B | | DS75451 | SN75451B | SG75451 | |
| μA75452A | | DS75452 | SN75452B | SB75452 | |
| μA75453A | | DS75453 | SN75453B | | |
| μA75453B | | DS75453 | SN75453B | SG75453 | |
| μA75461 | | DS75461 | SN75461 | SG75461 | |
| μA75462 | | DS75462 | SN75462 | SG75462 | |
| μA75471 | | | SN75471 | | |
| μA75472 | | | SN75472 | | |
| **Bus Transceivers and Repeaters** | | | | | |
| μA9640 | MC26S10,<br>MC3340<br>MC3344 | DS26S10 | AM26S10 | | |
| μA9679 | | | | | |
| μA96176 | | DS3695 | SN75176 | | |
| μA96177 | | DS3697 | SN75177 | | |
| μA96178 | | | SN75178 | | |

## Dual Line Drivers and Receivers

| Device | Type | Package Type | Package Codes |
|---|---|---|---|
| μA9614 | Dual Differential Line Driver | 16-L DIP | DC (6B), DM (6B), PC (9B) |
| μA9615 | Dual Differential Line Driver | 16-L DIP | DC (6B),DM (6B), PC (9B) |
| μA9636A | Dual Programmable Slew Rate Driver, RS-423 | 8-L DIP | RM (6T), RC (6T), TC (9T) |
| μA9637A | Dual Differential Line Receiver, RS-422/423 | 8-L DIP, SO-8 | RM (6T), RC (6T), TC (9T), SC (KC) |
| μA9638 | Dual High-Speed Differential Line Driver, RS-422 | 8-L DIP, SO-8 | RM (6T), RC (6T), TC (9T), SC (KC) |
| μA9639A | Dual Differential Line Receiver, RS-232C/422/423 | 8-L DIP | TC (9T) |
| μA9643 | Dual TTL-to-MOS/CCD Driver | 8-L DIP | TC (9T) |
| μA55107A | Dual Line Receiver | 14-L DIP | DM (6A) |
| μA75107A | | 14-L DIP, SO-14 | DC (6A), PC (9A), SC (KD) |
| μA75107B | | 14-L DIP, SO-14 | DC (6A), PC (9A), SC (KD) |
| μA75108B | | 14-L DIP, SO-14 | PC (9A), SC (KD) |
| μA55110A | Dual Line Driver, RS-232C | 14-L DIP | DM (6A) |
| μA75110A | | 14-L DIP, SO-14 | DC (6A), PC (9A), SC (KD) |
| μA75150 | | 14-L DIP | PC (9A) |
| μA75150 | | 8-L DIP, SO-8 | RC (6T), TC (9T), SC (KC) |

## Quad Line Drivers and Receivers

| Device | Type | Package Type | Package Codes |
|---|---|---|---|
| υA1488 | Quad Line Driver, RS-232C | 14-L DIP, SO-14 | DC, PC, SC (6A, 9A, KD) |
| µA1489 | Quad Line Receiver, RS-232C | 14-L DIP, SO-14 | DC, PC, SC (6A, 9A, KD) |
| µA1489A | | 14-L DIP | DC, PC (6A, 9A) |
| µA26LS31 | Quad High-Speed Diff. Line Driver, RS-422 | 16-L DIP | DC, PC (7B, 9B) |
| µA26LS32 | Quad Differential Line Receiver, RS-422/423 | 16-L DIP | DC, PC (7B, 9B) |
| µA3486 | Quad Line Receiver w/3-State Outputs, RS-422/423 | 16-L DIP | DC, PC (7B, 9B) |
| µA3487 | Quad Line Driver w/3-State Outputs, RS-422/423 | 16-L DIP | DC, PC (7B, 9B) |
| µA9645 | Quad TTL-to-MOS/CCD Driver | 16-L DIP | DC, PC (7B, 9B) |
| µA9665 | High Current/Voltage Darlington Driver | 16-L DIP | DC, PC (6B, 9B) |
| µA9666 | | | |
| µA9667 | | | |
| µA9668 | | | |
| µA75154 | Quad Line Receiver, RS-232C | 16-L DIP | DC, PC (6B, 9B) |
| µA75491 | MOS-to-LED Segment and Digit Driver | 14-L DIP | PC (9A) |
| µA75492 | | 14-L DIP | PC (9A) |
| µA96172 | Quad Differential Line Driver, RS-485 | 16-L DIP | DC, PC (7B, 9B) |
| µA96174 | | 16-L DIP | DC, PC (7B, 9B) |
| µA96173 | Quad Differential Line Receiver, RS-485 | 16-L DIP | DC, PC (7B, 9B) |
| µA96175 | | 16-L DIP | DC, PC, (7B, 9B) |

## Peripheral Drivers

| Device | Type | Package Type | Package Codes |
|---|---|---|---|
| μA75450 | Dual Positive AND | 14-L DIP | DC, PC (6A, 9A) |
| μA75451A | | 8-L DIP, SO-8 | RC, TC, SC (6T, 9T, KC) |
| μA75451B | | 8-L DIP | |
| μA75461 | | 8-L DIP | TC (9T) |
| μA75471 | | 8-L DIP | TC (9T) |
| μA75452A | Dual Positive NAND | 8-L DIP, SO-8 | TC, SC (9T, KC) |
| μA75462 | | 8-L DIP | TC (9T) |
| μA75472 | | 8-L DIP | TC (9T) |
| μA75453A | Dual Positive OR | 8-L DIP, SO-8 | RC, TC, SC (6T, 9T, KC) |
| μA75453B | | | |

## Bus Transceivers and Repeaters

| Device | Type | Package Type | Package Codes |
|---|---|---|---|
| μA9640 | Quad General-Purpose Transceiver | 16-L DIP | DM, DC, PC (6B, 9B) |
| μA9679 | Differential Repeater, RS-422A/485 | 8-L DIP | TC (9T) |
| μA75177 | Differential Repeater, RS-422A/485 | 8-L DIP, SO-8 | RC, TC, SC (6T, 9T, KC) |
| μA75178 | | | |
| μA96176 | Differential Transceiver, RS-422A/485 | 8-L DIP | RC, TC (6T, 9T) |
| μA96177 | Differential Repeater, RS-422A/485 | 8-L DIP | RC, TC (6T, 9T) |
| μA96178 | | 8-L DIP | RC, TC (6T, 9T) |

# Linear

For additional Linear products, see pages 67 and 431.

# Linear

The linear product line includes both specialized high-performance interface circuits and a broad line of industry standard components. A wide selection of interface, op amps, and voltage regulators are available. Fairchild continues to maintain a leadership position in high-reliability products by providing the largest selection of JAN QPL available anywhere.

## Op Amps

Included in this family are a wide variety of single, dual, and quad op amps that encompasses general-purpose, low power, JFET input, high-speed, and precision amplifiers. The family also includes several high-performance comparators.

## Voltage Regulators

A broad range of fixed, programmable, positive, and negative regulators are included in Fairchild's linear families.

## QB-883 Processing

An alpha suffix of QB indicates conformance to Class "B" process requirements of MIL-STD-883 to Fairchild MIL temperature range data sheet electricals. For complete information on MIL-STD-883, JAN, and other aerospace/defense product availability, contact your National Sales Representative.

**Linear Part Numbering System**

XXXXX X X X

Temperature Range
C (Commercial) = 0°C to + 70°C
V (Industrial) = − 40°C to + 85°C
M (Military/Extended) = − 55°C to + 125°C

Package Code
D = Dual In-Line (Hermetic, Ceramic)
F = Flatpack (Hermetic)
G = Flatpack (Brazed)
H = 8-Lead Metal
J = Dual In-Line (Side-Brazed)
K = Metal Power (TO-3)
L = Leadless Ceramic Chip Carrier (LCC)
P = Dual In-Line (Molded)
Q = Plastic Leaded Chip Carrier (PLCC)
R = 8-Lead Dual In-Line (Hermetic, Ceramic)
S = Small Outline Integrated Circuit (SOIC)
T = 8-Lead Dual In-Line (Molded)
U = Power, Molded (TO-220)
W = 8-Lead Molded (TO-92 Outline)
K = 8-Lead Surface-Mount (SO-8)

Electrical Class (If Used)

Device Type

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# Operational Amplifiers

## Single Operational Amplifiers, Externally Compensated

| Device | Type | Input Offset Voltage $V_{IO}$ (mV) (Max) | Input Bias Current $I_{IB}$ (Max) | Input Offset Current $I_{IO}$ (nA) (Max) | Input Offset Voltage Temp. Sensitivity $\Delta V_{IO}/\Delta T$ (μV/°C) (Typ) | Large Signal Voltage Gain $A_{VS}$ (V/mV) (Min) | Common Mode Rejection CMR (dB) (Min) | Power Supply Rejection Ratio PSRR (dB) (Min) | Supply Voltage (± V) | Operating Temp. (Note 1) | Package Codes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| μA101 | General-Purpose | 6.0 | 1.5 μA | 500 | 6.0 | 25 | 70 | 70 | 22 | M | 5W |
| μA201 | | 10.0 | 2.0μA | 750 | 10.0 | 15 | 65 | 70 | 22 | C | 5W, 9T |
| μA101A | General-Purpose | 3.0 | 100 nA | 20 | 6.0 | 25 | 80 | 80 | 22 | M | 5W |
| μA201A | | 3.0 | 100 nA | 20 | 6.0 | 25 | 80 | 80 | 22 | V | 5W |
| μA301A | | 10.0 | 300 nA | 70 | 6.0 | 15 | 70 | 70 | 18 | C | 5W, 9T, KC |
| μA108 | Super Beta | 3.0 | 3 nA | 0.4 | 3.0 | 25 | 85 | 80 | 20 | M | 5W |
| μA208 | | 3.0 | 3 nA | 0.4 | 3.0 | 25 | 85 | 80 | 20 | V | 5W |
| μA308 | | 10.0 | 10 nA | 1.5 | 6.0 | 15 | 80 | 80 | 18 | C | 5W, 9T, KC |
| μA108A | Super Beta | 1.0 | 3 nA | 0.4 | 1.0 | 40 | 96 | 96 | 20 | M | 5W |
| μA208A | | 1.0 | 3 nA | 0.4 | 1.0 | 40 | 96 | 96 | 20 | V | 5W |
| μA308A | | 0.73 | 10 nA | 1.5 | 1.0 | 60 | 96 | 96 | 18 | C | 5W, 9T, KC |
| μA709 | High-Performance | 6.0 | 1500 nA | 200 | 3.0 | 25 | 70 | 150 (Note 2) | 18 | M | 5W |
| μA709A | | 3.0 | 600 nA | 50 | 1.8 | 25 | 80 | 150 (Note 2) | 18 | M | 5W |
| μA709C | | 10.0 | 2000 nA | 750 | | 15 | 65 | 200 (Note 2) | 18 | C | 5W, 9A, 9T, KC |
| μA715 | High-Speed | 7.5 | 750 nA | 250 | | 10 | 74 | 300 (Note 2) | 18 | M | 5X, 6A |
| μA715C | | 10.0 | 1500 nA | 250 | | 8 | 74 | 400 (Note 2) | 18 | C | 5X, 6A |
| μA725 | Instrumentation | 1.5 | 100 nA | 20 | 0.6 | 250 | 115 | 20 (Note 2) | 22 | M | 5W, 9T |
| μA725A | | 0.75 | 70 nA | 4 | 0.6 | 500 | 115 | 8 (Note 2) | 22 | M | 5W |
| μA725C | | 3.5 | 125 nA | 35 | 2.0 | 125 | 115 | 20 (Note 2) | 22 | C | 5W |
| μA725E | | 0.75 | 70 nA | 4 | 0.6 | 500 | 115 | 8 (Note 2) | 22 | C | 5W |
| μA748 | High-Performance | 6.0 | 5000 nA | 200 | | 25 | 70 | 150 (Note 2) | 22 | M | 5W |
| μA748C | | 7.5 | 500 nA | 300 | | 15 | 70 | 150 (Note 2) | 22 | C | 5W, 6T, 9T, KC |

Note 1: Operating Temperature: C = 0°C to + 70°C, V = − 40°C to + 85°C, M = − 55°C to + 125°C.
Note 2: Power Supply Rejection Ratio measured in μV/V.

# Operational Amplifiers (Continued)

## Single Operational Amplifiers, Internally Compensated

| Device | Type | Input Offset Voltage $V_{IO}$ (mV) (Max) | Input Bias Current $I_{IB}$ (Max) | Input Offset Current $I_{IO}$ (nA) (Max) | Input Offset Voltage Temp. Sensitivity $\Delta V_{IO}/\Delta T$ ($\mu$V/°C) (Typ) | Large Signal Voltage Gain $A_{VS}$ (V/mV) (Min) | Common Mode Rejection CMR (dB) (Min) | Power Supply Rejection Ratio PSRR (dB) (Min) | Supply Voltage (± V) | Operating Temp. (Note 1) | Package Codes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| μA714 | Precision | 200 μV | 6.0 nA | 5.6 | 1.3 | 150 | 106 | 94 | 22 | M | 5W |
| μA714C | | 250 μV | 9.0 nA | 8.0 | 1.6 | 100 | 97 | 86 | 22 | C | 5W, 9T, KC |
| μA714E | | 130 μV | 5.5 nA | 5.3 | 1.3 | 180 | 103 | 90 | 22 | C | 5W |
| μA714L | | 400 μV | 60 nA | 40 | 3.0 | 80 | 94 | 83 | 18 | C | 5W, 9T, KC |
| μA741 | High-Performance | 6.0 | 5000 nA | 200 | | 25 | 70 | 150 (Note 2) | 22 | M | 5W, 6T |
| μA741A | | 4.0 | 210 nA | 70 | 15.0 | 32 | 80 | 50 (Note 2) | 22 | M | 5W, 6T |
| μA741C | | 7.5 | 800 nA | 300 | | 15 | | | 18 | C | 5W, 6T, 9T, KC |
| μA741E | | 4.0 | 210 nA | 70 | 15.0 | 32 | 80 | 50 (Note 2) | 22 | C | 5W, 6T, 9T |
| μA759 | Power | 4.5 | 300 nA | 60 | | 25 | 80 | 80 | 18 | M | 5W |
| μA759C | | 7.5 | 400 nA | 100 | | 25 | 70 | 80 | 18 | C | 5W, 8Z |
| μA77000 | | 10.0 | 400 nA | 100 | | 25 | 70 | 80 | 18 | C | 8Z |
| μA771 | JFET | 13.0 | 8 nA | 4 | 10.0 | 25 | 70 | 70 | 18 | C | 6T, 9T, KC |
| μA771AM | | 5.0 | 50 nA | 20 | 10.0 | 25 | 80 | 80 | 18 | M | 6T |
| μA771AC | | 4.0 | 4 nA | 2 | 10.0 | 25 | 80 | 80 | 18 | C | 6T, 9T, KC |
| μA771BM | | 5.0 | 50 nA | 20 | 10.0 | 25 | 80 | 80 | 18 | M | 6T |
| μA771BC | | 7.0 | 4 nA | 2 | 10.0 | 25 | 80 | 80 | 18 | C | 6T, 9T, KC |
| μA771LC | | 20.0 | 8 nA | 4 | 10.0 | 25 | 70 | 70 | 18 | C | 6T, 9T, KC |
| μA776 | Programmable | 7.5 | 7.5 nA | 5 | | 100 | 70 | 150 (Note 2) | 18 | M | 5W |
| μA776C | | 7.5 | 10 nA | 6 | | 50 | 70 | 200 (Note 2) | 18 | C | 5W, 9T |

Note 1: Operating Temperature: C = 0°C to + 70°C, V = − 40°C to + 85°C, M = − 55°C to + 125°C.
Note 2: Power Supply Rejection Ratio measured in μV/V.

# Operational Amplifiers (Continued)

## Dual Operational Amplifiers, Internally Compensated

| Device | Type | Input Offset Voltage $V_{IO}$ (mV) (Max) | Input Bias Current $I_{IB}$ (Max) | Input Offset Current $I_{IO}$ (nA) (Max) | Input Offset Voltage Temp. Sensitivity $\Delta V_{IO}/\Delta T$ (μV/°C) (Typ) | Large Signal Voltage Gain $A_{VS}$ (V/mV) (Min) | Common Mode Rejection CMR (dB) (Min) | Power Supply Rejection Ratio PSRR (dB) (Min) | Supply Voltage (± V) | Operating Temp. (Note 1) | Package Codes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| μA747 | General-Purpose | 6.0 | 0.5 μA | 200 | 15 max | 25 | 70 | 30 (Note 2) | 22 | M | 5X, 6A |
| μA747A | | 4.0 | 210 nA | 70 | 15 max | 32 | 80 | 15 (Note 2) | 22 | M | 5X, 6A |
| μA747C | | 7.5 | 800 nA | 300 | 15 max | 15 | 70 | 30 (Note 2) | 18 | C | 5X, 6A, 9A, KD |
| μA747E | | 4.0 | 210 nA | 70 | 15 max | 32 | 80 | 15 (Note 2) | 18 | C | 5X, 6A |
| μA772 | JFET | 13.0 | 8 nA | 4 | 10 | 25 | 70 | 70 | 30 | C | 6T, 9T, KC |
| μA772A | | 4.0 | 4 nA | 2 | 10 | 25 | 80 | 80 | 30 | M | 6T |
| μA772A | | 4.0 | 4 nA | 2 | 10 | 25 | 80 | 80 | 30 | C | 6T, 9T, KC |
| μA772B | | 7.0 | 4 nA | 2 | 10 | 25 | 80 | 80 | 30 | M | 6T |
| μA772B | | 7.0 | 4 nA | 2 | 10 | 25 | 80 | 80 | 30 | C | 6T, 9T, KC |
| μA772L | | 20.0 | 8 nA | 4 | 10 | 25 | 70 | 70 | 30 | C | 6T, 9T, KC |
| μA798 | Dual | 7.5 | 400 nA | 200 | 10 | 15 | 70 | 30 (Note 2) | 3-36 | C | 9T, KC |
| μA1458 | High-Performance | 7.5 | 0.8 μA | 0.3 μA | 15 | 15 | 70 | 30 (Note 2) | 18 | C | 5W, 6T, 9T, KC |
| μA1458C | | 12.0 | 1.0 μA | 0.4 μA | 15 | 15 | 60 | 30 (Note 2) | 18 | C | 5W, 6T, 9T |
| μA1558 | | 6.0 | 1.5 μA | 0.5 μA | 15 | 25 | 70 | 30 (Note 2) | 22 | M | 5W, 6T |

Note 1: Operating Temperature: C = 0°C to + 70°C, V = − 40°C to + 85°C, M = − 55°C to + 125°C.
Note 2: Power Supply Rejection Ratio measured in μV/V.

# Operational Amplifiers (Continued)

## Quad Operational Amplifiers, Internally Compensated

| Device | Type | Input Offset Voltage $V_{IO}$ (mV) (Max) | Input Bias Current $I_{IB}$ (nA) (Max) | Input Offset Current $I_{IO}$ (nA) (Max) | Input Offset Voltage Temp. Sensitivity $\Delta V_{IO}/\Delta T$ ($\mu$V/°C) (Typ) | Large Signal Voltage Gain $A_{VS}$ (V/mV) (Min) | Common Mode Rejection CMR (dB) (Min) | Power Supply Rejection Ratio PSRR (dB) (Min) | Supply Voltage (± V) | Operating Temp. (Note 1) | Package Codes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| µA124 | Quad | 7.0 | 300 | 100 | 7 | 25 | 70 | 65 | 32 | M | 6A |
| µA224 | | 7.0 | 300 | 100 | 7 | 25 | 70 | 65 | 32 | V | 6A, 9A |
| µA324 | | 9.0 | 500 | 150 | 7 | 15 | 65 | 65 | 32 | C | 6A, 9A, KD |
| µA2902 | | 10.0 | 500 | 200 | 7 | 15 | 50 | 50 | 32 | V | 9A |
| µA148 | General-Purpose | 6.0 | 325 | 75 | | 25 | 70 | 77 | 22 | M | 6A |
| µA248 | | 7.5 | 500 | 125 | | 25 | 70 | 77 | 18 | V | 6A, 9A |
| µA348 | | 7.5 | 400 | 100 | | 15 | 70 | 77 | 18 | C | 6A, 9A |
| µA774 | JFET | 13.0 | 8 | 4 | 10 | 25 | 70 | 70 | 18 | C | 7A, 9A, KD |
| µA774A | | 4.0 | 4 | 2 | 10 | 25 | 80 | 80 | 18 | C | 7A, 9A |
| µA774A | | 5.0 | 50 | 20 | 10 | 25 | 80 | 80 | 18 | M | 7A |
| µA774B | | 7.0 | 4 | 2 | 10 | 25 | 80 | 80 | 18 | C | 7A, 9A |
| µA774B | | 8.0 | 50 | 20 | 10 | 25 | 80 | 80 | 18 | M | 7A |
| µA774L | | 20.0 | 8 | 4 | 10 | 25 | 70 | 70 | 18 | C | 7A, 9A |
| µA3303 | Quad | 10.0 | 1000 | 250 | 10 | 15 | 70 | 150 (Note 2) | 36 | V | 6A, 9A |
| µA3403 | | 10.0 | 800 | 200 | 10 | 15 | 70 | 150 (Note 2) | 36 | C | 6A, 9A, KD |
| µA3503 | | 6.0 | 1200 | 200 | 10 | 25 | 70 | 150 (Note 2) | 36 | M | 6A |
| µA4136 | Quad | 7.5 | 800 | 300 | | 15 | 70 | 150 (Note 2) | 18 | C | 6A, 9A, KD |

Note 1: Operating Temperature: C = 0°C to + 70°C, V = − 40°C to + 85°C, M = − 55°C to + 125°C.
Note 2: Power Supply Rejection Ratio measured in µV/V.

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# Operational Amplifiers (Continued)

## Operational Amplifiers Cross-Reference Guide

| Device | Type | Fairchild | Motorola | National | TI | SG | Signetics |
|---|---|---|---|---|---|---|---|
| LM101 | General-Purpose | μA101 | | LM101 | LM101 | SG101 | |
| LM201 | | μA201 | | LM201 | TC201 | SG201 | |
| LM101A | General-Purpose | μA101A | LM101A | LM101A | LM101A | SG101A | LM101A |
| LM201A | | μA201A | LM201A | LM201A | LM201A | SG201A | LM201A |
| LM301A | | μA301A | LM301A | LM301A | LM301A | SG301A | LM301A |
| LM108 | Super Beta | μA108 | LM108 | LM108 | LM108 | SG108 | |
| LM208 | | μA208 | LM208 | LM208 | LM208 | SG208 | |
| LM308 | | μA308 | LM308 | LM308 | LM308 | SG308 | |
| LM108A | Super Beta | μA108A | LM108A | LM108A | | SG108A | |
| LM208A | | μA208A | LM208A | LM208A | | SG208A | |
| LM308A | | μA308A | LM308A | | | SG308A | |
| LM124 | Quad | μA124 | LM124 | LM124 | LM124 | SG124 | LM124 |
| LM224 | | μA224 | LM224 | LM224 | LM224 | SG224 | LM224 |
| LM324 | | μA324 | LM324 | LM324 | LM324 | SG324 | LM324 |
| μA2902 | | μA2902 | | | | | |
| LM148 | Quad General-Purpose | μA148 | LM148 | | LM148 | | |
| LM248 | | LM248 | LM248 | LM248 | LM248 | | |
| LM348 | | LM348 | LM348 | LM348 | LM348 | | |
| μA709 | High-Performance | μA709 | MC1709 | LM709 | μA709 | | |
| μA714 | High Precision | μA714 | | | μA714 | | |
| μA715 | High-Speed | μA714 | | | | | |
| μA725 | Instrumentation | μA714 | | | | | |
| μA741 | General-Purpose | μA741 | MC1741 | LM741 | μA741 | SG741 | μA741 |
| μA747 | Dual General-Purpose | μA747 | MC1747 | LM747 | μA747 | SG747 | μA747 |
| μA748 | High-Performance | μA747 | MC1748 | LM748 | μA748 | SG748 | μA748 |
| μA759 | Power | μA759 | | | | | |
| μA77000 | | μA77000 | | | | | |
| μA771 | Single JFET | μA771 | MC34001 | LF351 | TL071/81 | | |
| μA772 | Dual JFET | μA772 | MC34002 | LF353 | TL072/82 | | |
| μA774 | Quad JFET | μA774 | MC34004 | LF347 | TL074 | | |
| μA776 | Programmable | μA776 | MC1776 | | | | |
| LM798 | Dual | μA798 | MC3458/*<br>MC3558* | LM358* | LM358* | | LM358* |
| MC1458 | Dual High-Performance | μA1458 | MC1458 | LM1458 | MC1458 | SG1458 | MC1458 |
| μA1558 | | | | | | | |
| μA3303 | Quad | μA3303 | | | | | |
| MC3403 | | μA3403 | MC3403 | | MC3403 | | MC3403 |
| μA3503 | | μA3503 | | | | | |
| RC4136 | Quad | μA4136 | | | RC4136 | | |

# Operational Amplifiers (Continued)

## Comparators

| Device | Type | Input Offset Voltage $V_{IO}$ (mV) (Max) | Input Bias Current $I_{IB}$ (Max) | Input Offset Current $I_{IO}$ (nA) (Max) | Response Time $t_{PD}$ (ns) (Typ) | Output Sink Current $I_{OL}$ (mA) (Min) | Large Signal Voltage Gain $A_{VS}$ (V/mV) (Typ) | Supply Voltage (V) | Operating Temp. (Note 1) | Package Codes |
|---|---|---|---|---|---|---|---|---|---|---|
| µA111 | Voltage | 4.0 | 150 nA | 20 | 200 | | 200 | 5 − ± 15 | M | 5W |
| µA311 | | 10.0 | 300 nA | 70 | 200 | | 200 | 5 − ± 15 | C | 5W, 9T, KC |
| µA139 | Quad | 9.0 | 300 nA | + 100 | 1.3 µs | 6.0 | 200 | 36 or + 18 | M | 6A |
| µA239 | | 9.0 | 400 nA | + 150 | 1.3 µs | 6.0 | 200 | 36 or + 18 | V | 6A, 9A, KD |
| µA339 | | 9.0 | 400 nA | + 150 | 1.3 µs | 6.0 | 200 | 36 or + 18 | C | 6A, 9A, KD |
| µA2901 | Quad | 15.0 | 500 nA | 200 | 300 | 6.0 | 100 | 36 or + 18 | V | 6A, 9A |
| µA3302 | | 40.0 | 1000 nA | 300 | 300 | 2.0 | 30 | 28 or + 14 | V | 6A, 9A, KD |
| µA685 | High-Speed | 2.0 | 10 µA | + 1 µA | 9.5 | | | + 7 | M | 5X, 6B |
| µA685 | | 2.0 | 10 µA | + 1 µA | 12.0 | | | + 7 | V | 5X, 6B, 9B, KD |
| µA6685 | Ultra-Fast | 3.0 | 10 µA | + 1 µA | 2.7 | | | + 7 | M | 5X, 6B |
| µA6685 | | 3.5 | 10 µA | + 1 µA | 2.7 | | | + 7 | V | 5X, 6B, 9B, KD |
| µA687 | Dual High-Speed | 3.0 | 10 µA | + 1 µA | 20.0 | | | + 7 | M | 6B |
| µA687 | Differential | 3.5 | 10 µA | + 1 µA | 14.0 | | | + 7 | V | 6B, 9B |
| µA687A | | 3.0 | 10 µA | + 1 µA | 12.5 | | | + 7 | M | 6B |
| µA687A | | 3.5 | 10 µA | + 1 µA | 10.0 | | | + 7 | V | 6B, 9B |
| µA6687 | Ultra-Fast Voltage | 3.0 | 10 µA | + 1 µA | 4.0 | | | + 7 | M | 6B |
| µA6687 | | 3.0 | 10 µA | + 1 µA | 4.0 | | | + 7 | V | 6B, 9B |
| µA710 | High-Speed | 3.0 | 45 µA | 3 µA | 40.0 | 0.5 | 800 (Note 2) | + 14, − 7 | M | 5W, 6A |
| µA710 | | 6.5 | 40 µA | 5 µA | 40.0 | 0.5 | 1000 (Note 2) | + 14, − 7 | V | 5W, 6A, 9A |
| µA711 | Dual High-Speed | 6.0 | 150 µA | 20 µA | 40.0 | 0.5 | 500 (Note 2) | + 14, − 7 | M | 5X, 6A |
| µA711 | | 4.5 | 150 µA | 25 µA | 40.0 | 0.5 | 500 (Note 2) | + 14, − 7 | C | 5X, 6A, 9A |
| µA760 | High-Speed | 6.0 | 60 µA | 7.5 µA | 18.0 | | | + 8, − 8 | M | 5W, 6A, 6T |
| µA760 | | 6.0 | 60 µA | 7.5 µA | 18.0 | | | + 8, − 8 | V | 5W, 6A, 6T |

Note 1: Operating Temperature: C = 0°C to + 70°C, V = − 40°C to + 85°C, M = − 55°C to + 125°C.
Note 2: Large Signal Voltage Gain measured in V/V.

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# Operational Amplifiers (Continued)

## Comparators Cross-Reference Guide

| Device | Type | Fairchild | Motorola | National | TI | SG | Signetics |
|---|---|---|---|---|---|---|---|
| LM111 | Voltage | μA111 | LM111 | LM111 | LM111 | SG111 | LM111 |
| LM311 | | μA311 | LM311 | LM311 | LM111 | SG111 | LM111 |
| LM139 | Quad | μA139 | LM139 | LM139 | LM139 | SG139 | LM139 |
| LM239 | | μA239 | LM239 | LM239 | LM239 | SG239 | LM239 |
| LM339 | | μA339 | LM339 | LM339 | LM339 | SG339 | LM339 |
| MC685 | High-Speed | μA685 | MC685 | | | | |
| MC6685 | Ultra-Fast | μA6685 | MC6685 | | | | |
| MC687 | Dual High-Speed Differential | μA687 | MC687 | | | | |
| μA687A | | μA687A | | | | | |
| MC6687 | | μA6687 | MC6687 | | | | |
| μA710 | High-Speed Differential | μA710 | MC1710 | LM710 | μA710 | SG710 | |
| μA711 | Dual High-Speed | μA711 | MC1711 | LM711 | μA711 | SG711 | |
| μA760 | High-Speed Differential | μA760 | | LM760 | | | |
| μA2901 | Quad | μA2901 | LM2901 | LM2901 | LM2901 | | LM2901 |
| μA3302 | | μA3302 | MC3302 | LM3302 | LM3302 | | |

## Special Functions

| Device | | Supply Voltage (V) | Operating Temperature* | Package Codes |
|---|---|---|---|---|
| μA555 | Single Timing Circuit | + 18 | C | 9T, KC |
| μA556 | Dual Timing Circuit | + 18 | C | 9A |
| μA592 | Differential Video Amplifier | + 8 | M | 6A |
| μA592 | | + 8 | C | 6A, 9A, 9T, KC |
| μA733 | | + 8 | M | 5X, 6A |
| μA733 | | + 8 | C | 5X, 6A, 9A, KD |
| μA2240 | Programmable Timer/Counter | 18 | C | 7B, 9B |
| μA3046 | Transistor Array | | C | 9A, KD |
| μA3086 | | | V | 6A, 9A, KD |
| μA3680 | Quad Telephone Relay Driver | BAT + 20 | V | 6A, 9A, KD |
| μA7392 | DC Motor Speed Control Circuit | 6.3 – 16 | V | 6A, 9A |

*Operating Temperature: C = 0°C to + 70°C, V = – 40°C to + 85°C, M = – 55°C to + 125°C.

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

## Operational Amplifiers (Continued)

### Special Functions Cross-Reference Guide

| Device | Type | Fairchild | Motorola | National | TI | SG | Signetics |
|---|---|---|---|---|---|---|---|
| NE555 | Single Timing Circuit | μA555 | MC1455 | LM555 | NE555 | SG555 | NE555 |
| NE556 | Dual Timing Circuit | μA556 | MC3456 | LM556 | NE556 | SG556 | NE556 |
| NE592 | Differential Video Amplifier | μA592 | NE592 | LM592 | TL592 |  | NE592 |
| μA733 |  | μA733 | MC1733 | LM733 | μA733 | SG733 | μA733 |
| μA2240 | Programmable Timer/Counter | μA2240 |  |  | μA2240 |  |  |
| μA3046 | Transistor Array | μA3046 |  |  |  |  |  |
| μA3086 |  | μA3086 |  |  |  |  |  |

# Voltage Regulators

## Fixed Output Voltage Regulators

| Device | Type | Standard $V_{OUT}$ Range (V) | Standard $I_{OUT}$ | Input Voltage $V_{IN}$ (V) Min/Max | Average Temperature Coefficient Output Voltage $\Delta V_O/\Delta T$ (mV) | Regulation | | Package Type | Package Codes (Package Suffix) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Line | Load | | |
| | | | | | | (mV Max) | | | |
| **Positive Output** | | | | | | | | | |
| μA109M | 3-Terminal | 4.7–5.4 | 1A | 35 | 2.0 Max | 50 | 100 | TO-39, TO-3 | HM, KM (XC, YC) |
| μA209C | | | | | | | | TO-3 | KC (YC) |
| μA309C | | | | | | | | TO-3 | KC (YC) |
| μA7805M | 3-Terminal | 4.8–5.2 | 1A | 35–40 | 0.3/0.4 Max | 50 | 100 | TO-3 | KM (HJ) |
| μA7805C | | 4.8–5.2 | | | 1.1 Typ | 50 | 100 | TO-3, TO-220 | KC, UC (HJ, GH) |
| μA7806C | | 5.75–6.25 | | | 0.8 Typ | 120 | 120 | TO-3, TO-220 | KC, UC (HJ, GH) |
| μA7808M | | 7.7–8.3 | | | 0.3/0.4 Max | 80 | 100 | TO-3 | KM (HJ) |
| μA7808C | | 7.7–8.3 | | | 0.8 Typ | 160 | 160 | TO-3, TO-220 | KC, UC (HJ, GH) |
| μA7812M | | 11.5–12.5 | | | 0.3/0.4 Max. | 120 | 120 | TO-3 | KM (HJ) |
| μA7812C | | 11.5–12.5 | | | 1.0 Typ | 240 | 240 | TO-3, TO-220 | KC, UC (HJ, GH) |
| μA7815M | | 14.4–15.6 | | | 0.3/0.4 Max | 150 | 150 | TO-3 | KM (HJ) |
| μA7815C | | 14.4–15.6 | | | 1.0 Typ | 300 | 300 | TO-3, TO-220 | KC, UC (HJ, GH) |
| μA7818M | | 17.3–18.7 | | | 0.3/0.4 Max | 180 | 180 | TO-3 | KM (HJ) |
| μA7818C | | 17.3–18.7 | | | 1.0 Typ | 360 | 360 | TO-3, TO-220 | KC, UC (HJ, GH) |
| μA7824M | | 23.0–25.0 | | | 0.3/0.4 Max | 240 | 240 | TO-3 | KM (HJ) |
| μA7824C | | 23.0–25.0 | | | 1.5 Typ | 480 | 480 | TO-3, TO-220 | KC, UC (HJ, GH) |
| μA7885C | | 8.15–8.85 | | | 0.8 Typ | 170 | 170 | TO-220 | UC* (GH) |
| μA78L05 | 3-Terminal | 4.8–5.2 | 100 mA | 35 | – 0.65 Typ | 150 | 60 | TO-92, SO-8 | AWC/V, ASC/V (EI, KC) |
| μA78L62 | | 5.95–6.45 | | | – 0.75 Typ | 175 | 80 | TO-92 | AWC/V (EI) |
| μA78L82 | | 7.87–8.53 | | | – 0.8 Typ | 175 | 80 | TO-92 | AWC/V (EI) |
| μA78L09 | | 8.64–9.36 | | | – 0.9 Typ | 200 | 90 | TO-92 | AWC/V (EI) |
| μA78L12 | | 11.5–12.5 | | | – 1.0 Typ | 250 | 100 | TO-92 | AWC/V (EI) |
| μA78L15 | | 14.4–15.6 | | | – 1.3 Typ | 300 | 150 | TO-92 | AWC/V (EI) |
| μA78M05M | 3-Terminal | 4.8–5.2 | 500 mA | 35–40 | 0.3/0.4 Max | 50 | 50 | TO-39 | HM (FC) |
| μA78M05C | | 4.8–5.2 | | | 1.0 Typ | 100 | 100 | TO-39, TO-220 | HC, UC (FC, GH) |
| μA78M06M | | 5.75–6.25 | | | 0.3/0.4 Max | 60 | 60 | TO-39 | HM (FC) |
| μA78M06C | | 5.75–6.25 | | | 0.5 Typ | 100 | 120 | TO-39, TO-220 | HC, UC (FC, GH) |
| μA78M08M | | 7.7–8.3 | | | 0.3/0.4 Max | 60 | 80 | TO-39 | HM (FC) |
| μA78M08C | | 7.7–8.3 | | | 0.5 Typ | 100 | 160 | TO-39, TO-220 | HC, UC (FC, GH) |
| μA78M12M | | 11.5–12.5 | | | 0.3/0.4 Max | 60 | 120 | TO-39 | HM (FC) |
| μA78M12C | | 11.5–12.5 | | | 1.0 Typ | 100 | 240 | TO-39, TO-220 | HC, UC (FC, GH) |
| μA78M15M | | 14.4–15.6 | | | 0.3/0.4 Max | 60 | 150 | TO-39 | HM (FC) |
| μA78M15C | | 14.4–15.6 | | | 1.0 Typ | 100 | 300 | TO-39, TO-220 | HC, UC (FC, GH) |
| μA78M24M | | 23.0–25.0 | | | 0.3/0.4 Max | 60 | 240 | TO-39 | HM (FC) |
| μA78M24C | | 23.0–25.0 | | | 1.2 Typ | 100 | 480 | TO-39, TO-220 | HC, UC (FC, GH) |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# Voltage Regulators (Continued)

## Fixed Output Voltage Regulators (Continued)

| Device | Type | Standard $V_{OUT}$ Range (V) | Standard $I_{OUT}$ | Input Voltage $V_{IN}$ (V) Min/Max | Average Temperature Coefficient Output Voltage $\Delta V_O/\Delta T$ (mV) | Regulation Line | Regulation Load | Package Type | Package Codes (Package Suffix) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | (mV Max) | (mV Max) | | |
| **Negative Output** | | | | | | | | | |
| µA7905M | 3-Terminal | − 4.8− − 5.2 | 1A | − 35 | 0.3 Max | 50 | 100 | TO-3 | KM (HJ) |
| µA7905C | | − 4.8− − 5.2 | | | 0.4 Typ | 100 | 100 | TO-3, TO-220 | KC, UC (HJ, GH) |
| µA7908M | | − 7.7− − 8.3 | | | 0.3 Max | 80 | 100 | TO-3 | KM (HJ) |
| µA7908C | | − 7.7− − 8.3 | | | 0.6 Typ | 160 | 160 | TO-3, TO-220 | KC, UC (HJ, GH) |
| µA7912M | | − 11.5− − 12.5 | | | 0.3 Max | 120 | 120 | TO-3 | KM (HJ) |
| µA7912C | | − 11.5− − 12.5 | | | 0.8 Typ | 240 | 240 | TO-3, TO-220 | KC, UC (HJ, GH) |
| µA7915M | | − 14.4− − 15.6 | | | 0.3 Max | 150 | 150 | TO-3 | KM (HJ) |
| µA7915C | | − 14.4− − 15.6 | | | 1.0 Typ | 300 | 300 | TO-3, TO-220 | KC, UC (HJ, GH) |
| µA79M05M | 3-Terminal | − 5.2− − 4.8 | 500 mA | − 35 | 0.3 Max | 50 | 100 | TO-3 | HM (FC) |
| µA79M05C | | − 5.2− − 4.8 | | | 0.4 Typ | 50 | 100 | TO-3, TO-220 | HC, UC (FC, GH) |
| µA79M08M | | − 8.3− − 7.7 | | | 0.3 Max | 80 | 160 | TO-3 | HM (FC) |
| µA79M08C | | − 8.3− − 7.7 | | | 0.6 Typ | 80 | 160 | TO-3, TO-220 | HC, UC (FC, GH) |
| µA79M12M | | − 12.5− − 11.5 | | | 0.3 Max | 80 | 240 | TO-3 | HM (FC) |
| µA79M12C | | − 12.5− − 11.5 | | | 0.8 Typ | 80 | 240 | TO-3, TO-220 | HC, UC (FC, GH) |
| µA79M15M | | − 15.6− − 14.4 | | | 0.3 Max | 80 | 240 | TO-3 | HM (FC) |
| µA79M15C | | − 15.6− − 14.4 | | | 1.0 Typ | 80 | 240 | TO-3, TO-220 | HC, UC (FC, GH) |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# Voltage Regulators (Continued)

## Fixed Output Voltage Regulators Cross-Reference Guide

| Device | Type | Fairchild | National | Motorola | TI |
|---|---|---|---|---|---|
| LM109 | 3-Terminal | μA109 | LM109K | LM109K | |
| μA7805 | 3-Terminal | μA7805 | LM78XXCT | MC78XXCT | μA78XXCKC |
| μA7806 | | μA7806 | LM78XXCK | MC78XXCK | |
| μA7808 | | μA7808 | LM78XXCK | MC78XXCK | |
| μA7812 | | μA7812 | LM140K/XX | MC78XXX | |
| μA7815 | | μA7815 | LM340T-XX | | |
| μA7818 | | μA7818 | LM340K-XX | | |
| μA7824 | | μA7824 | | | |
| μA7885 | | μA7885 | LM340T-XX | | |
| μA78L05 | 3-Terminal | μA78L05 | LM78LXXACZ | MC78LXXACP | μA78LXXCLP |
| μA78L09 | | μA78L09 | | | |
| μA78L12 | | μA78L12 | | | |
| μA78L15 | | μA78L15 | | | |
| μA78L62 | | μA78L62 | | | |
| μA78L82 | | μA78L82 | | | |
| μA78M05 | 3-Terminal | μA78M05 | LM78MXXCP | MC78MXXCT | μA78MXXCKC |
| μA78M06 | | μA78M06 | | | |
| μA78M08 | | μA78M08 | | MC78MXXCG | |
| μA78M12 | | μA78M12 | | | |
| μA78M15 | | μA78M15 | LM341-XX | | |
| μA78M24 | | μA78M24 | | | |
| μA7905 | 3-Terminal | μA7905 | LM79XXCT | MC79XXCT | μA79XXCKC |
| μA7908 | | μA7908 | LM79XXCK | MC79XXCK | |
| μA7912 | | μA7912 | LM120K-XX | MC79XX | |
| μA7915 | | μA7915 | LM320T/K-XX | | |
| μA79M05 | 3-Terminal | μA79M05 | LM79MXXCP | MC79MXXCT | μA79MXXCKC |
| μA79M08 | | μA79M08 | | | |
| μA79M12 | | μA79M12 | | | |
| μA79M15 | | μA79M15 | | | |

# Voltage Regulators (Continued)

## Adjustable Output Voltage Regulators

| Device | Type | Standard $V_{OUT}$ Range (V) | Standard $I_{OUT}$ | Input Voltage $V_{IN}$ (V) Min/Max | Regulation Line (%/V) Max | Regulation Load (%) Max | Package Type | Package Codes (Package Suffix) |
|---|---|---|---|---|---|---|---|---|
| **Positive Output** | | | | | | | | |
| µA105M | Adjustable | 4.5–40 | 12 mA | 8.5–50 | 0.06 | 0.1 | TO-99 8-Lead | HM (5W) |
| µA305 | | 4.5–30 | | 8.5–40 | 0.06 | 0.1 | TO-99 8-Lead | HC (5W) |
| µA305A | | 4.5–40 | | 8.5–50 | 0.06 | 0.4 | TO-99 8-Lead | HC (5W) |
| µA376 | | 5.0–37 | | 9.0–40 | 0.03 | 0.5 | 8-Lead DIP | TC (9T) |
| µA117M | 3-Terminal | 1.2-37 | 1.5A | | 0.02 | 15 mV | TO-3 | KM (HJ) |
| µA217V | | | | | 0.02 | 15 mV | TO-3, TO-220 | KV, UV (HJ, GH) |
| µA317C | | | | | 0.04 | 25 mV | TO-3, TO-220 | KC, UC (HJ, GH) |
| µA138M | 5-Amp | 1.2–32 | 5A | | 0.01 | 15 mV | TO-3 | KM (FT) |
| µA238V | | | | | 0.01 | 15 mV | TO-3 | KV (FT) |
| µA338C | | | | | 0.03 | 25 mV | TO-3, TO-220 | KC, UC (FT, GH) |
| µA150M | 3-Amp | 2–37 | 3A | | 0.01 | 15 mV | TO-3 | KM (FT) |
| µA250V | | | | | 0.01 | 15 mV | TO-3 | KV (FT) |
| µA350C | | | | | 0.03 | 25 mV | TO-3, TO-220 | KC, UC (FT, GH) |
| µA723M | General-Purpose | 2–37 | 150 mA | 9.5–40 | 0.01 | 0.15 | 10-Lead Metal | HM, DM (5X, 6A) |
| µA723C | | | | | 0.01 | 0.20 | 10-Lead Metal,<br>14-Lead DIP,<br>SO-14 | HC, DC, PC, SC<br>(5X, 6A, 9A, KD) |
| µA78G | 4-Terminal | 5–30 | 1A | 7.5–40 | 1.0 | 1.0 | TO-202 | U1C (8Z) |
| µA78MG | | | | | 1.0 | 1.0 | Power Pack | U1C (8Z) |
| **Negative Output** | | | | | | | | |
| µA79G | 4-Terminal | – 30– – 2.23 | 1A | – 40– – 7 | 1.0 | 1.0 | TO-202 | U1C (8Z) |
| µA79MG | | | | | 1.0 | 1.0 | Power Pack | U1C (8Z) |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# Voltage Regulators (Continued)

## Adjustable Output Voltage Regulators Cross-Reference Guide

| Device | Type | Fairchild | National | Motorola | TI |
|---|---|---|---|---|---|
| μA105 | Adjustable | μA105 | LM105H | | |
| μA305 | | μA305 | LM305H | | |
| μA305A | | μA305A | LM305AH | | |
| μA376 | | μA376 | LM376N | | |
| LM117 | 3-Terminal | μA117 | LM117K | LM117K | |
| LM217 | | μA217 | LM217K | LM217K | LM217KC |
| LM317 | | μA317 | LM317T/K | LM317T/K | LM317KC |
| μA138 | 5-Amp | μA138 | LM138K | | |
| μA238 | | μA238 | LM238K | | |
| μA338 | | μA338 | LM338K | | |
| μA150 | 3-Amp | μA150 | LMJ150K | LM150K | |
| μA250 | | μA250 | LM250K | LM250K | |
| μA350 | | μA350 | LM350K/T | LM350K/T | LM350KA/C |
| μA723 | General-Purpose | μA723 | LM723CH, H, CN, CJ, J | MC1723CG, CP, CL, L | μA723CN, CJ, J |
| μA78G | 4-Terminal | μA78G | | | |
| μA78MG | | μA78MG | | | |
| μA79G | 4-Terminal | μA79G | | | |
| μA79MG | | μA79MG | | | |

# Voltage Regulators (Continued)

## Switching Regulators and Voltage References

| Device | Type | $V_{CC}$ Range (V) | Package Type | Package Codes (Package Suffix) |
|---|---|---|---|---|
| μA431A | Adjustable Precision Zener Shunt | 2.5–36 | TO-92<br>SO-8 | WC, WV (EI)<br>SC (KC) |
| μA494V/C | Pulse-Width Modulated | 7–40 | 16-Lead DIP | PV, DC, PC (9B, 7B) |
| μA1524A | Pulse-Width Modulated | 5 | 16-Lead DIP | DM (7B) |
| μA2524A | | | | DV, PV (7B, 9B) |
| μA3524A | | | | PC, DC (9B, 7B) |
| μA78S40M | Universal | 2.5–40 | 16-Lead DIP | DM (9B) |
| μA78S40V/C | | | | PV, PC, DC (9B, 7B) |

## Switching Regulators and Voltage References Cross-Reference Guide

| Device | Type | Fairchild | National | Motorola | TI |
|---|---|---|---|---|---|
| TL431A | Adjustable Shunt/Precision Zener | μA431A | | TL431CLP | TL431CLP |
| TL494 | Pulse-Width Modulated Switching | μA494 | | TL494CN, CJ, MJ | TL494CN, CJ, MJ |
| μA1524A | Pulse-Width Modulated Switching | μA1524A | LM1524 | | EG1524 |
| μA2524A | | μA2524A | LM2524 | | EG2524 |
| μA3524A | | μA3524A | LM3524 | | EG3524 |
| μA78S40 | Switching | μA78S40 | | μA78S40PC, DC, DM | |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# CLASIC

The Fairchild Customizable Linear Applications Specific Integrated Circuits (CLASIC) approach brings to the systems designer a level of sophistication that will enable VLSI solutions requiring analog and mixed analog/digital functions to be integrated cost effectively. The CLASIC approach offers:

- Bipolar and CMOS technologies
- Standard cell and array methodologies
- Customer CAD tools that allow design and simulation with higher level building blocks

The CLASIC system considerably reduces the time and the risks associated with VLSI designs by offering a cell library of such pre-designed, commonly identified function blocks as op amps, comparators, DACs, VCO, PLL, gates, flip-flops and counters, and the CAD tools to combine these blocks. The designer's task is somewhat more complicated, yet similar to designing a printed circuit board using standard ICs.

Most importantly, however, with the CLASIC approach, the customer can select the level of design participation desired. At the lowest level, the customer can simply provide a functional description of the desired design and a CLASIC applications engineer will translate this into a standard cell schematic. As the user gains experience and confidence with the CLASIC approach, any level of design up through layout can be accomplished with the appropriate CAD tools at the designer's facility, if desired. The designer can choose the options that best match both needs and experience.

## The Cell Library

There are presently over 150 cells in the CLASIC library, covering a broad range of linear and digital functions, and cells are being added continually.

The linear performance offered by the Bipolar CLASIC cells is based on an NPN $f_t$ of 2.5 GHz and a PNP $f_t$ of 40 MHz. The logic cells are based on high-performance ECL technology, offering gate delays of 1.5 ns at fanouts of 3 and D flip-flop toggle frequencies of greater than 100 MHz.

The CMOS cell library is presently based on a 3-micron double-poly process that provides offset voltages of less than 5 mV, unity gain BW of 2 MHz, gate delays of 5 ns at fanouts of 3, and D flip-flop toggle frequencies greater than 50 MHz.

## Semicustom Packaging

| | |
|---|---|
| PLCC | Plastic Leaded (J-Bend) Chip Carrier |
| CLCC | Ceramic Leaded (J-Bend) Chip Carrier |
| CPGA | Ceramic Pin Grid Array |
| LDCC | Leaded Chip Carrier |
| LCC | Leadless Chip Carrier |
| FPK | Flatpak |
| CDIP | Ceramic Dual In-Line |
| PDIP | Plastic Dual In-Line |

## CLASIC Customer CAD Tools

A PC-based CAD system is CLASIC's main vehicle for extending access of Fairchild's technologies to the customer. CLASIC's macro cell library is supported on a number of popular and high performance CAD systems. The combination of CLASIC's macro cell library and the CAD software allow the system engineer to carry out an ASIC development project up to the layout stage. All necessary databases required for schematic capture, netlist translation, and simulation are included. The table summarizes CLASIC's library products.

Library maintenance service and training on the CAD systems are available. Training includes the use of the databases supplied, macro cell applications, and designing with CLASIC.

Instantaneous access to CLASIC's macro cells, reliable simulation models, and a direct tie-in to CLASIC's manufacturing facilities are the principal advantages to using CLASIC library products. Coupled with the PC CAD tools, CLASIC library products let you start designing ASIC almost immediately and, in the process, save a significant portion of the development charges by doing the design yourself.

CLASIC's macro cells encompass a wide range of commonly used system functions from op-amps and comparators, to high-level functional blocks such as DAC and a complete AGC subsystem. Similar to off-the-shelf products, CLASIC macro cells are supported with detailed data sheets and application notes. Unlike off-the-shelf products, however, parameters not specified in the data sheets can still be obtained by simulation without having to build special test circuits. Parasitics associated with high performance cells have been extracted and incorporated into the SPICE subcircuit file of the cell to insure correlation between simulation results and actual silicon performance. Fundamental to the reliability of any simulation result is the basic process model used to characterize the low level transistor and resistor devices. CLASIC's SPICE models are derived from extensive characterization efforts spanning many wafers and fabrication lots. Models are available for all standard geometry NPN and PNP transistors, Schottky transistors, resistors, and parasitic diodes. Simulation of circuit performance over manufacturing variations is also possible with worst-case models in the database.

**CLASIC Macro Cell Library Products**

| CLASIC Product No. | Computer Platform | CAD Software | Product Description |
|---|---|---|---|
| CCAT1-CT/A<br>CCAT1-CT/S<br>CCVX1-CT/A<br>CCVX1-CT/S | PC AT<br>PC AT<br>VAX<br>VAX | CASE Technology<br>CT-1000, CT-2000 | • Run with CASE Technology CAD software<br>• Cell and component symbols<br>• Cell subcircuit database (PSpice format)<br>• Typical and worst-case SPICE models |
| CCAT1-VL/A<br>CCAT1-VL/S<br>CCVX1-VL/A<br>CCVX1-VL/S | PC AT<br>PC AT<br>VAX<br>VAX | ViewLogic's Workview<br>CAD Products Running<br>PSpice or SPICE | • Run with ViewLogic CAD software<br>• Cell and component symbols<br>• Cell subcircuit database (PSpice format)<br>• Typical and worst-case SPICE models |
| CCAT1-CD/A<br>CCAT1-CD/S<br>CCVX1-CD/A<br>CCVX1-CD/S | PC AT<br>PC AT<br>VAX<br>VAX | IBM CIEDS CAD<br>Software | • Run with IBM's CIEDS CAD software<br>• Cell and component symbols<br>• Cell subcircuit database (PSpice format)<br>• Typical and worst-case SPICE models |

# CLASIC (Continued)

## Op-Amps

| Cell Reference | Cell Description | Similar Industry Standard | Cell Area Units | Cell Power (mW) |
|---|---|---|---|---|
| BUF201 | Voltage Follower Ground-Sensing 16X NPN Output | | 0.8 A | 3.0 |
| BUF301 | Voltage Follower w/Resistor Input Divider | | 0.8 A | 4.0 |
| OPGM101 | Low-Power Transconductance | | 0.5 A | 3.0 |
| OPGP101 | General-Purpose | µA741 | 1.0 A | 6.5 |
| OPGP124 | Ground-Sensing 124-Type | LM124 | 0.8 A | 5.0 |
| OPGP201 | General-Purpose Low-Power | LM101A | 0.7 A | 4.0 |
| OPGP301 | General-Purpose 7 MHz BW, 2.5 V/µs Slew Rate | µA741A | 1.0 A | 6.5 |
| OPHS101 | High-Speed 22 MHz BW, 42 V/µs Slew Rate | LM118 | 2.0 A | 40.0 |
| OPLB101 | Low-Input Bias Current 10 nA, 6 MHz BW, 2.3 V/µs | LM108 | 1.3 A | 10.0 |
| OPLN101 | Low-Noise Voltage 4 nV/rt Hz, 12 MHz BW | OP27 | 1.6 A | 18.0 |
| OPNR101 | Norton Current Mode 40 MHz BW, 26 V/µs Slew Rate | LM159 | 0.7 A | 20.0 |
| OPLV101 | Low-Input Offset Voltage 0.1 mV $V_{OS}$, 4.5 MHz BW, 2 V/µs | OP07 | 1.2 A | 8.0 |
| OPSS101 | 124-Type 5 MHz BW, 2 V/µs | LM124 | 0.7 A | 4.0 |

## AGC Functions

| Cell Reference | Cell Description | Cell Area Units | Cell Power (mW) |
|---|---|---|---|
| AGCAMP01 | AGC Amp w/ DC Restore, 20 MHz BW | 2.0 A | 8.0 |
| AGCCON01 | Control Amp for GCAMP301 | 0.5 A | 3.0 |
| CONAM101 | Fast-Response AGC Control Amp | 0.8 A | 6.0 |
| CONAMP01 | Control Amp for AGCAMP | 0.9 A | 6.0 |
| FWR101 | AGC Rectifier | 0.5 A | 2.0 |
| GCA101 | AGC Amp 25 MHz BW, 30 dB Range | 2.0 A | 8.0 |
| GCA102 | High-Gain AGC Amp, Low-Noise Version of GCAMP301 | 2.0 A | 9.0 |
| GCALN101 | Current-Out AGC Amp, 25 MHz BW, 30 dB Range | 2.0 A | 8.0 |
| GCAMP201 | Low-Noise AGC Amp, Wider Range | 2.0 A | 9.0 |
| GCAMP401 | AGC Amp, Differential Input/Output | 2.0 A | 8.0 |

# CLASIC (Continued)

## Comparators

| Cell Reference | Cell Description | Cell Area Units | Cell Power (mW) |
|---|---|---|---|
| CMPEC101 | ECL, < 10 ns Delay | 0.8 A | 22.0 |
| CMPLS101 | Level Shifter for use with CMPEC101 | 0.8 A | 1.0 |
| CMPGP101 | General-Purpose < 200 ns Delay | 0.8 A | 5.0 |
| CMPGP201 | General-Purpose < 100 ns Ground-Sensing | 0.8 A | 7.0 |
| CMPGP301 | General-Purpose 20 MHz, ECL Output | 1.0 A | 35.0 |
| CMPHS101 | High-Speed 50 MHz, < 20 ns | 1.2 A | 40.0 |
| CMPHS201 | High-Speed 75 MHz, < 15 ns | 1.3 A | 50.0 |
| CMPLS201 | TTL Level Shifter for CMPHS201 | 0.1 A | 1.0 |
| CMPHS301 | High-Speed Differential Input/Output | 1.5 A | 35.0 |
| CMPHY101 | High-Speed w/Hysteresis, 0–100 mV | 0.9 A | 7.0 |
| CMPHY201 | Ground-Sensing w/Hysteresis, 0–100 mV | 1.0 A | 8.0 |
| CMPHY301 | High-Speed Hysteresis, ECL Output | 1.0 A | 9.0 |
| CMPTTL01 | TTL, < 20ns | 0.7 A | 10.0 |
| CMP3MX01 | Three-Input, < 10 ns | 0.7 A | 6.0 |
| CMPTTL01 | Set/Reset Latch | 1.0 A | 8.0 |
| DFECL101 | ECL Gain-Stage Differential, Input/Output | 0.3 A | 3.0 |
| PRCMP01 | 12-Bit, for use in AC/DC, < 20 ns | 4.0 A | 50.0 |

## Voltage References

| Cell Reference | Cell Description | Cell Area Units | Cell Power (mW) |
|---|---|---|---|
| VBG101 | Band-Gap, 3%, 1.25V | 1.0 A | 5.0 |
| BSVCC03 | 12V–5V Zener, 10% | 0.4 A | 3.0 |
| BGTRIM | Band-Gap Trim Cell, Zener Zap Elements | 0.5 A | |
| VBG201 | Band-Gap, 2%, 1.25V | 1.0 A | 6.0 |
| ZAP201 | Band-Gap Trim Cell, Zener Zap Elements | 0.5 A | |
| VBG203 | Band-Gap, 1%, 2.5V | 1.0 A | 6.0 |
| ZAP101 | Band-Gap Trim Cell, Zener Zap Elements | 0.5 A | |
| AGCREF | For AGC Amp, Resistor Ratio | 0.1 A | 1.0 |
| FAIL5 | Under-Voltage Detector for 5V, 4.3V Nominal Trip Point Adjustable | 1.1 A | 4.0 |
| FAIL12 | Under-Voltage Detector for 12V, 10.2V Nominal Trip Point Adjustable | 1.1 A | 4.0 |
| VBG | Band-Gap, 0.5%, 2.5V | | |

# CLASIC (Continued)

## Data Acquisition

| Cell Reference | Cell Description | Cell Area Units | Cell Power (mW) |
|---|---|---|---|
| DAC8B101 | 8-Bit Current Output, $I_{OUT}/I_{OUT}$ Inverting | 3.3 A | 15.0 |
| SW2H | Fast-Sample/Hold, Diode Bridge $< 50$ ns | 1.0 A | 20.0 |
| SW2L | Lower Power SW2H, $< 100$ ns | 1.0 A | 10.0 |
| SH | Sample/Hold, High-Speed, 15 V/$\mu$s External Hold Capacitor | 0.7A | 25.0 |
| SHSW | Sample/Hold Switch, ECL Input | 1.0 D | 2.0 |

## Interface

| Cell Reference | Cell Description | Cell Area Units | Cell Power (mW) |
|---|---|---|---|
| OUTA101 | 200 mA Source Output Driver | 4.0 A | 50.0 |
| OUTB101 | 200 mA Sink Output Driver | 4.0 A | 50.0 |

## Bias Cells

| Cell Reference | Cell Description | Cell Area Units | Cell Power (mW) |
|---|---|---|---|
| BIASA101 | Analog Bias Temperature-Compensated | 0.4 A | 27.0 |
| BIASD101 | Digital Bias Temperature-Compensated | 1.4 D | 12.0 |
| BIASZ101 | Peripheral Bias | 1.7 D | 12.0 |
| AGCB101 | Bias for GCA101 | 0.5 A | 25.0 |
| PDBIAS04 | Bias for 8464 | 0.5 A | 25.0 |
| BIASA201 | Lower AC Output Impedance (w/Cap.) | 0.6 A | 27.0 |
| BIASD201 | Lower AC Output Impedance (w/Cap.) | 2.5 D | 12.0 |
| PKBS | Bias for PKDET | 0.5 A | 20.0 |
| BIASD102 | Digital ECL Logic Family Bias Sink Cell | 1.4 D | 15.0 |

# CLASIC (Continued)

## Logic Cells

| Cell Reference | Cell Description | Cell Area Units | Cell Power (mW) |
|---|---|---|---|
| FFD101 | D Flip-Flop 140 MHz Max. Clock | 3.4 D | 5.0 |
| GEXOR101 | 2-Input Exclusive-OR/NOR, 2–4 ns Delay | 1.4 D | 0.9 |
| GxOR101 | 2-5 Input OR/NOR Family, Medium Power/Speed 1.6–1.9 ns Delay | 1 to 1.5 D | 1.8 |
| GxORF101 | 2-5 Input OR/NOR Fast Family, High Power/Speed 1–1.3 ns Delay | 1 to 1.5 D | 2.8 |
| GxORL101 | 2-5 Input OR/NOR Low-Power Family, 2.6–3.3 ns Delay | 1 to 1.5 D | 1.3 |
| NAND101 | TTL NAND Totem-Pole Output, 3 ns | 2.0 D | 4.0 |
| NAND201 | TTL NAND Open-Collector Output, 5 ns | 1.5 D | 3.0 |
| DFFLOP01 | FFD101 w/o Set/Reset | 3.4 D | 5.0 |
| PDLY201 | ECL Delay Cell, 30 ns | 2.0 D | 2.0 |
| TTECL201 | TTL/ECL Converter, no Pad | 2.0 D | 7.5 |
| TTLXOR | TTL XOR Gate Open Collector | 1.0 D | 2.5 |
| FFD201 | FFD101 w/One Pull-Down on Q | 1.0 D | 5.0 |
| AND101 | 1-Input TTL and Open Collector | 1.0 D | 2.0 |
| AND201 | 1-Input TTL and Open Collector | 1.0 D | 2.0 |
| INVERTER | Simple Inverter | 0.7 D | 1.5 |
| CHGPMPD | Open-Collector Inverter | 0.5 D | 1.5 |
| DELAYZ2 | TTL Delay Cell | 0.8 D | 1.8 |
| DELAY03 | ECL Delay Cell | 0.8 D | 1.8 |
| S3ORF101 | 3-Input OR ECL w/no Pull-Down | 1.3 D | 1.8 |
| PULRES02 | ECL 1-Input w/Pull-Up | 1.0 D | 1.8 |
| FFTOG101 | Divide-by-Two Low-Power | 3.0 D | 3.0 |
| ED101 | Rising-Edge Detector, 5–15 ns Pulse Output | 2.0 D | 3.0 |
| MS101 | One-Shot 555-Type Timer w/o F-F, Differential Output | 4.0 D | 7.0 |
| ONES01 | Negative-Edge-Triggered One-Shot, Differential Output | 6.0 D | 6.0 |
| EDGS02 | Negative Edge-Triggered, 10 ns, One-Shot | 2.0 D | 2.0 |
| EDGL01 | Negative-Edge-Triggered, Programmable One-Shot | 3.0 D | 3.0 |
| ECTLT101 | ECL-to-TTL Converter, no Pad | 2.0 D | 3.5 |
| ECTLR101 | ECL-to-TTL Converter, no Pad | 2.0 D | 7.0 |
| TTECL101 | TTL/ECL Differential Output | 1.5 D | 2.0 |
| GEXOR201 | Exclusive-OR/NOR Differential, Input/Output | 1.5 D | 1.0 |
| ONEST101 | One-Shot | 5.0 D | 4.0 |
| TOUTOC | Open-Collector Output | 3.0 D | 7.0 |
| TOUTCH | High-Current Open-Collector | 4.0 D | 8.0 |
| TOUTCP | Reverse-Phase Tout Open Collector | 3.0 D | 7.0 |
| CMPLS101 | Emitter-Follower ECL Driver | 0.2 D | |
| PLUP | ECL 1-Input Differential In | 0.2 D | |
| PULRES02 | ECL 1-Input w/Pull-Up/Down | 0.3 D | |
| RCVR101 | ECL Differential Outputs | 1.0 D | 1.0 |
| FFASD101 | Set/Reset Latch | 0.2 D | |
| TRIGEN03 | Unity-Gain ECL Stage-Differential In/Out | 4.0 D | 4.0 |
| CONV02 | ECL-Gain Stage-Differential In/Out | 0.8 D | 1.0 |
| SWTH03 | ECL 2:1 Multiplexer | 1.5 D | 1.5 |

# CLASIC (Continued)

## Bonding Pad Cells

| Cell Reference | Cell Description | Cell Area Units | Cell Power (mW) |
|---|---|---|---|
| ZPAD101 | Bonding Pad | 0.2 A | |
| ZPIN101 | Pad with TTL/ECL Converter | 3.1 D | 3.3 |
| ZPOUT101 | Pad with ECL/TTL Converter | 4.3 D | 7.5 |
| ZPOUT301 | ECL-to-TTL 20 mA Output | 2.5 D | 3.0 |
| ZPROT401 | Schottky Clamp to VEED | 0.5 D | |
| ZPIN201 | TTL In, Complementary ECL Output | 3.0 D | 3.5 |
| BUF101 | ECL Buffer, High-Current Output | 1.5 D | |
| ZPROT301 | Small ZPROT101 | 0.7 D | |
| ZPOUT201 | Pad with 20 mA ECL/TTL Converter | 5.0 D | 8.0 |
| ZPROT201 | ESD Protection | 0.8 D | |
| ZPROT101 | ESD Protection w/Bias | 0.8 D | |

# CLASIC (Continued)

## Special Cells

| Cell Reference | Cell Description | Cell Area Units | Cell Power (mW) |
|---|---|---|---|
| PKDET101 | Peak Detector | 1.1 A | 10.0 |
| BKBS101 | Bias Cell for PKDET101 | 0.5 A | 5.0 |
| TIME101 | 555 Timer | 1.0 A | 1.5 |
| PKDCUR | Current Sources for PKDET101 | 0.3 A | |
| GATEPK01 | Gated Peak Detector, 15 V/μs | 1.5 A | 12.0 |
| PKDET | Peak Detector, 3-State, Fast Charge/ Discharge/Hold | 1.2 A | 12.0 |
| SW1 | Fast Peak Detector, 5 MHz BW | 0.5 A | 2.0 |
| AGCPK101 | Peak Detector for AGC Cell, Rectifier and Dual Filters | 0.5 A | 3.0 |
| READWT03 | 1 μs and 2 μs Delay Elements | 1.0 A | 5.0 |
| DIFFWR01 | Full-Wave Rectifier w/Differentiator | 0.8 A | 4.0 |
| FWRDIF101 | Full-Wave Rectifier w/Differentiator | 0.8 A | 6.0 |
| 3MUX01 | 321 Mux Amp Input | 1.0 A | 2.0 |
| MUXOP124 | 124 Op Amp used w/Mux 2 MHz BW | 1.0 A | 15.0 |
| VTOI101 | Analog Level Shifter, V-to-I Converter | 0.5 A | 3.0 |
| FREC | Full-Wave Rectifier, Differential Input/Single-Ended Output | 0.5 A | 2.0 |
| VCO05 | VCO 50 MHz, 1% Linearity | 0.7 A | 20.0 |
| OSRMP101 | Oscillator, Medium Frequency Range | 2.0 A | 15.0 |
| IX2MIR | Subcell, Wilson PNP Current Mirror | 0.3 A | 2.0 |
| INTQ | Current Mirror, 4 Outputs, 10:1 Ratio, PNP 1X | 0.2 A | |
| INTBIQR | Current Output Cell for Op Amp, Darlington NPN 2X | 0.2 A | |
| CHGPMP101 | Charge Pump, Medium Speed | 0.8 A | 5.0 |
| VCO70Y | VCO 70 MHz, 1% Linearity | 1.0 A | 25.0 |
| CHGPMP03 | Charge Pump, Differential Outputs, Variable Charge/Discharge Rate | 4.0 D | 20.0 |
| CHGPMP05 | CHGPMP03 w/Small PNP | 4.0 D | 20.0 |
| CHGPMP | Single-Ended TTL Charge Pump, 5 ns Minimum Output Pulse | 0.8 A | 10.0 |
| CHGPMPY | Charge Pump, Dual Rate, Adjustable Differential | 4.0 D | 15.0 |
| LVS202 | Current Source 150 μA NPN Output | 0.2 A | 2.0 |
| LOGP1C | Logic Level Shifter 2 VD | 0.2 A | 1.0 |

## Components

| Cell Reference | Cell Description | Cell Area Units |
|---|---|---|
| CxPF | Capacitor Cells 1, 2, 5, 10 pF ± 10%, 0.5% Matching | 0.2-1.0A |
| RBx | Base Resistor Cells, 66Ω, 13KΩ ± 11%, 0.5% Matching | 0.1 A |
| RIx | Implant Resistor Cells, 450Ω, 55KΩ ± 22%, 1% Matching | 0.1 A |

# Logic

For additional Logic products, see pages 89 and 423.

# Logic

Representing over two decades of technology evolution, Fairchild's standard logic families provide SSI, MSI, and LSI solutions in TTL, ECL, and CMOS technologies. This comprehensive capability serves the widest possible application areas, from mainframes and workstations to office automation and portable systems. Fairchild's advanced-technology families are providing the highest performance available in the industry, as well as supporting customer designs in the hi-rel market.

## TTL Families

Products included in this group are the standard TTL, Low Power TTL, Schottky, Low Power Schottky, and FAST® families. Introduced in 1979, Fairchild Advanced Schottky TTL (FAST) logic has become the industry standard for new high-performance bipolar designs. FAST products feature a 30 % speed improvement at one-fifth the power of Schottky TTL products, plus improved noise margins, lower input current, and superior capacitive and line driving characteristics.

## ECL

Fairchild high-performance ECL product lines encompass the most popular industry standards available today. The ECL offerings also include a selection of the very fast SSI 11C family. See page 234 for ECL ASIC products.

For new designs, the logic of choice is the F100K family, which provides a number of enhancements: fast gate speeds with moderate edge rates, lower power consumption, full voltage and temperature compensation, extremely small parasitic capacitances, and complementary outputs. The F100K pin assignments minimize crosstalk, noise coupling, and feedthrough, making this the industry's easiest system design upgrade from TTL.

## CMOS

The Fairchild Advanced CMOS Technology (FACT™) product line is the industry's first CMOS high-performance standard logic family. By incorporating sub-2 micron technology and advanced design, the FACT product line offers 1 ns internal gate delays with a full 24 mA drive capability. In addition, the family provides a breakthrough in solving latch-up and ringing by using proprietary design techniques.

The family is offered in CMOS and TTL interface configurations with wide voltage (2V to 6V) and extended temperature range specifications. Intended as a replacement for Advanced Low Power Schottky (ALS) and HC product lines, the FACT family has set the next-generation standard for high speed and low power applications. See page 235 for CMOS ASIC product offerings.

CMOS devices are grouped in two categories:

| | |
|---|---|
| **AC** | Standard logic functions with CMOS-compatible inputs and TTL- and MOS-compatible outputs. |
| **ACT** | Standard logic functions with TTL-compatible inputs and TTL-and MOS-compatible outputs. |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

## Logic Part Numbering System

XXXXX X X XX

Special Variations
- QR = Commercial grade device with burn-in
- QB = Military grade device with environmental and burn-in processing
- T = Devices shipped in 7″ reels
- X = Devices shipped in 14″ reels
- TR = Commercial grade devices with burn-in shipped in 7″ reels
- XR = Commercial grade devices with burn-in shipped in 14″ reels

Temperature Range
- C (Commercial) = 0°C to + 70°C / + 75°C
- V (Industrial) = − 25°C to + 85°C
- A (Automotive) = − 40°C to + 85°C
- M (Military) = − 55°C to + 125°C

Package Code
- P = Plastic DIP
- SP = Slim Plastic DIP
- D = Ceramic DIP
- SD = Slim Ceramic DIP
- F = Flatpak
- L = Ceramic Leadless Chip Carrier (LCC)*
- Q = Plastic Chip Carrier (PCC)*
- S = Small Outline IC (SOIC), 150 mils

Device Type

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*For information on commercial availability, contact your local National Sales Representative.

# FACT (54AC/74ACXX) (54ACT/74ACTXX)

## Gates

| Device | Type | Inputs/ Gate | No. of Gates | Pins | Package Codes |
|---|---|---|---|---|---|
| **NAND** | | | | | |
| 54AC/74AC00 | Quad 2-Input | 2 | 4 | 14 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT00 | Quad 2-Input | 2 | 4 | 14 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC10 | Triple 3-Input | 3 | 3 | 14 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC20 | Dual 4-Input | 4 | 2 | 14 | PC, DC, SC, DM, FM, LM |
| **AND** | | | | | |
| 54AC/74AC08 | Quad 2-Input | 2 | 4 | 14 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC11 | Triple 3-Input | 3 | 3 | 14 | PC, DC, SC, DM, FM, LM |
| **OR/NOR, Exclusive-OR** | | | | | |
| 54AC/74AC02 | Quad 2-Input NOR | 2 | 4 | 14 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC32 | Quad 2-Input OR | 2 | 4 | 14 | PC, DC, SC, DM, FM, LM |
| **AND/OR Invert** | | | | | |
| 54AC/74AC04 | Hex Inverter | 1 | 6 | 14 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC14 | Hex Schmitt Trigger | 1 | 6 | 14 | PC, DC, SC, DM, FM, LM |

## Dual Edge-Triggered Flip-Flops

| Device | Type | Clock Edge | Direct Set | Direct Clear | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 54AC/74AC74 | D | Positive | X | X | 14 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT74 | D | Positive | X | X | 14 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC109 | J-K | Positive | X | X | 16 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT109 | J-K | Positive | X | X | 16 | PC, DC, SC, DM, FM, LM |

## Multiple Flip-Flops

| Device | Type | Master Reset | 3-State Outputs | Pins | Package Codes |
|---|---|---|---|---|---|
| 54AC/74AC174 | Hex D | X | | 16 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT174 | Hex D | X | | 16 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC175 | Quad D | X | | 16 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT175 | Quad D | X | | 16 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC273 | Octal D | X | | 20 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC374 | Octal D | | X | 20 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT374 | Octal D | | X | 20 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC377 | Octal D | | X | 20 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT377 | Octal D | | X | 20 | PC, DC, SC, DM, FM, LM |
| 74ACT534 | Octal D | | X | 20 | PC, DC, SC |
| 54ACT/74ACT564 | Octal D | | X | 20 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT574 | Octal D | | X | 20 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT821 | Octal D | X | | 24 | SPC, SDC, QC, DM, FM, LM |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# FACT (54AC/74ACXX) (54ACT/74ACTXX) (Continued)

## Shift Register

| Device | Type | Serial Inputs | Parallel Inputs | 3-State Outputs | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 54AC/74AC299 | 8-Bit Octal Storage | 2 | X | X | 20 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT323 | 8-Bit Octal Storage | 2 | X | X | 20 | PC, DC, SC, DM, FM, LM |

## Latches

| Device | Type | Enable Inputs (Level) | 3-State Outputs | Pins | Package Codes |
|---|---|---|---|---|---|
| 54AC/74AC373 | Octal | 1 (H) | X | 20 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT373 | Octal | 1 (H) | X | 20 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT563 | Octal D | | X | 20 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT573 | Octal D | | X | 20 | PC, DC, SC, DM, FM, LM |

## Counters

| Device | Type | Parallel Entry | Reset | Up/ Down | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 54AC/74AC161 | 4-Bit Binary | S | A | | 16 | PC, DC, SC, DM, FM, LM |
| 74ACT161 | 4-Bit Binary | S | A | | 16 | PC, DC, SC |
| 54AC/74AC163 | 4-Bit Binary | S | S | | 16 | PC, DC, SC, DM, FM, LM |
| 74ACT163 | 4-Bit Binary | S | S | | 16 | PC, DC, SC |
| 54AC/74AC169 | 4-Bit Binary | S | | X | 16 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC191 | 4-Bit Decade | A | | X | 16 | PC, DC, SC, DM, FM, LM |

S = Synchronous
A = Asynchronous

## Octal Buffers/Line Drivers

| Device | Enable Inputs (Level) | Inverting | Noninverting | Pins | Package Codes |
|---|---|---|---|---|---|
| 54AC/74AC240 | 2 (L) | X | | 20 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT240 | 2 (L) | X | | 20 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC241 | 1 (L), 1 (H) | | X | 20 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT241 | 1 (L), 1 (H) | | X | 20 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC244 | 2 (L) | | X | 20 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT244 | 2 (L) | | X | 20 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC540 | 2 (L) | X | | 20 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC541 | 1 (L), 1 (H) | | X | 20 | PC, DC, SC, DM, FM, LM |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# FACT (54AC/74ACXX) (54ACT/74ACTXX) (Continued)

## Transceivers

| Device | Type | Enable Inputs (Level) | 3-State Output | Pins | Package Codes |
|---|---|---|---|---|---|
| 54AC/74AC245 | Octal Bus | 1 (L) | X | 20 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT245 | Octal Bus | 1 (L) | X | 20 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC646 | Octal Bus w/Register | 1 (L), 1 (H) | X | 24 | SPC, SDC, SC, SDM |
| 54AC/74AC648 | Octal Bus w/Register | 1 (L), 1 (H) | X | 24 | SPC, SDC, SC, SDM |

## Multiplexers

| Device | Type | Enable Inputs (Level) | Outputs True | Outputs Complement | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 54AC/74AC151 | 8-Input | 1 (L) | X | X | 16 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT151 | 8-Input | 1 (L) | X | X | 16 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC153 | Dual 4-Input | 2 (L) | X | | 16 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT153 | Dual 4-Input | 2 (L) | X | | 16 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC157 | Quad 2-Input | 1 (L) | X | | 16 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT157 | Quad 2-Input | 1 (L) | X | | 16 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC158 | Quad 2-Input | 1 (L) | | X | 16 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT158 | Quad 2-Input | 1 (L) | | X | 16 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC251 | 8-Input | 1 (L) | X | X | 16 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT251 | 8-Input | I (L) | X | X | 16 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC253 | Dual 4-Input | 2 (L) | X | | 16 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT253 | Dual 4-Input | 2 (L) | X | | 16 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC257 | Quad 2-Input | I (L) | X | | 16 | PC, DC, SC, DM |
| 54ACT/74ACT257 | Quad 2-Input | 1 (L) | X | | 16 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC258 | Quad 2-Input | 1 (L) | | X | 16 | PC, DC, SC, DM, FM, LM |
| 74ACT258 | Quad 2-Input | 1 (L) | | X | 16 | PC, DC, SC |

## Decoders/Demultiplexers

| Device | Type | Address Inputs | Active Low Enable | Active High Enable | Active Low Outputs | Pins | Package Codes |
|---|---|---|---|---|---|---|---|
| 54AC/74AC138 | 1-of-8 | 3 | 2 | 1 | 8 | 16 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT138 | 1-of-8 | 3 | 2 | 1 | 8 | 16 | PC, DC, SC, DM, FM, LM |
| 54AC/74AC139 | Dual 1-of-4 | 2, 2 | 1, 1 | | 4, 4 | 16 | PC, DC, SC, DM, FM, LM |
| 54ACT/74ACT139 | Dual 1-of-4 | 2, 2 | 1, 1 | | 4, 4 | 16 | PC, DC, SC, DM, FM, LM |

## Specialized LSI

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| 74ACT708 | 64 × 9 FIFO Memory | 28 | PC, DC |
| 74ACT1010 | 16 × 16 Multiplier/Accumulator | 64 | DC |
| 74ACT1016 | 16 × 16 Multiplier | 64 | DC |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# FAST (54F/74FXX)

## Gates

| Device | Type | Inputs/ Gate | No. of Gates | Pins | Package Codes |
|---|---|---|---|---|---|
| **NAND/NAND Buffer** | | | | | |
| 54F/74F00 | Quad 2-Input | 2 | 4 | 14 | PC, DC, SC, DM, FM, LM |
| 54F/74F10 | Triple 3-Input | 3 | 3 | 14 | PC, DC, SC, DM, FM, LM |
| 54F/74F20 | Dual 4-Input | 4 | 2 | 14 | PC, DC, SC, DM, FM, LM |
| 74F30 | 8-Input | 8 | 1 | 14 | PC, DC, SC, DM, FM, LM |
| 74F37 | Quad 2-Input Buffer | 2 | 4 | 14 | PC, DC, SC |
| 54F/74F38 | Quad 2-Input Buffer | 2 | 4 | 14 | PC, DC, SC, DM, FM, LM |
| 74F40 | Dual 4-Input Buffer | 4 | 2 | 14 | SC, PC, DC |
| **AND** | | | | | |
| 54F/74F08 | Quad 2-Input | 2 | 4 | 14 | PC, DC, SC, DM, FM, LM |
| 54F/74F11 | Triple 3-Input | 3 | 3 | 14 | PC, DC, SC, DM, FM, LM |
| **OR/NOR, Exclusive-OR** | | | | | |
| 54F/74F02 | Quad 2-Input NOR | 2 | 4 | 14 | PC, DC, SC, DM, FM, LM |
| 74F27 | Triple 3-Input NOR | 3 | 3 | 14 | SC, PC, DC |
| 54F/74F32 | Quad 2-Input OR | 2 | 4 | 14 | PC, DC, SC, DM, FM, LM |
| 54F/74F86 | Quad 2-Input Exclusive-OR | 2 | 4 | 14 | PC, DC, SC, DM, FM, LM |
| **AND/OR-Invert** | | | | | |
| 54F/74F04 | Hex Inverter | 1 | 6 | 14 | PC, DC, SC, DM, FM, LM |
| 74F51 | AND/OR-Invert | 3/3/2/2 | | 14 | PC, DC, SC |
| 54F/74F64 | AND/OR-Invert | 4/2/3/2 | | 14 | PC, DC, SC, DM, FM, LM |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# FAST (54F/74FXX) (Continued)

## Flip-Flops/Registers

| Device | Type | FF Type | Pins | Package Codes |
|---|---|---|---|---|
| 54F/74F74 | Dual Positive Edge-Trigger | D | 14 | PC, DC, SC, DM, FM, LM |
| 54F/74F109 | Dual Positive Edge-Trigger | J-K | 16 | PC, DC, SC, DM, FM, LM |
| 74F112 | Dual Negative Edge-Trigger | J-K | 16 | PC, DC, SC |
| 74F113 | Dual Edge-Trigger | J-K | 14 | PC, DC, SC |
| 74F114 | Dual Negative Edge-Trigger | J-K | 14 | PC, DC, SC |
| 54F/74F174 | Hex Master Reset | D | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F175 | Quad Master Reset | D | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F374 | Octal, 3-State Outputs | D | 20 | PC, DC, SC, DM, FM, LM |
| 54F/74F378 | Parallel w/Enable | D | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F379 | Quad Parallel w/Enable | D | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F398 | Quad Register | 2-Port | 20 | PC, DC, SC, DM, FM, LM |
| 54F/74F399 | Quad Register | 2-Port | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F407 | Data Access Register |  | 24 | SPC, SDC, SDM, FM, LM |
| 54F/74F410 | Register Stack |  | 18 | DC, SC, DM |
| 54F/74F534 | Octal, 3-State Outputs | D | 20 | PC, DC, SC, DM, FM, LM |
| 54F/74F564 | Octal, 3-State Outputs | D | 20 | PC, DC, SC, DM, FM, LM |
| 54F/74F574 | Octal, 3-State Outputs | D | 20 | PC, DC, DM, FM, LM |
| 54F/74F821 | 10-Bit Master Reset | D | 24 | SPC, SDC, QC |
| 74F823 | 9-Bit Master Reset | D | 24 | SPC, SDC, QC |
| 74F825 | 8-Bit Master Reset | D | 24 | SPC, SDC, QC |

## Latches

| Device | Broadside Pinout | Inverting | Transparent | 3-State Outputs | No. of Bits | Pins | Package Codes |
|---|---|---|---|---|---|---|---|
| 54F/74F373 |  |  | X | X | 8 | 20 | PC, DC, SC, DM, FM, LM |
| 54F/74F412 |  |  | X | X | 8 | 24 | SPC, SDC, SDM, FM |
| 74F432 |  | X | X | X | 8 | 24 | SPC, SDC, SC |
| 54F/74F533 |  | X | X | X | 8 | 20 | PC, DC, SC, DM, FM, LM |
| 54F/74F563 | X | X | X | X | 8 | 20 | PC, DC, SC, DM, FM, LM |
| 54F/74F573 | X |  | X | X | 8 | 20 | PC, DC, SC, DM, FM, LM |
| 74F841 | X |  | X | X | 10 | 24 | SPC, SDC, QC |
| 74F843 | X |  | X | X | 9 | 24 | SDC, SPC, SC |
| 74F845 | X |  | X | X | 8 | 24 | SPC, SDC, SC |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# FAST (54F/74FXX) (Continued)

## Counters

| Device | Type | Up/ Down | Reset | Pins | Package Codes |
|---|---|---|---|---|---|
| 54F/74F160A | 4-Bit BCD Decade | | A | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F161A | 4-Bit Binary | | A | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F162A | 4-Bit BCD Decade | | S | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F163A | 4-Bit Binary | | S | 16 | PC, DC, SC, DM, FM, LM |
| 74F168 | 4-Bit BCD Decade | X | | 16 | PC, DC, SC |
| 74F169 | 4-Bit Binary | X | | 16 | PC, DC, SC |
| 54F/74F190 | 4-Bit BCD Decade | X | | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F191 | 4-Bit Binary | X | | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F192 | 4-Bit BCD Decade | X | A | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F193 | 4-Bit Binary | X | A | 16 | PC, DC, SC, DM, FM, LM |
| 74F269 | 8-Bit Binary | X | | 24 | SPC, SDC, SC |
| 74F525 | 16-Stage Programmable | | A | 28 | DC, SC |
| 74F568 | 4-Bit BCD Decade, 3S | X | S/A | 20 | PC, DC, SC |
| 74F569 | 4-Bit Binary, 3S | X | S/A | 20 | PC, DC, SC |

S = Synchronous
A = Asynchronous
3S = 3-State

## Shift Registers

| Device | Type | Serial Inputs | Parallel Inputs | 3-State Outputs | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 54F/74F164 | 8-Bit | 2 | | | 14 | PC, DC, SC, DM, FM, LM |
| 54F/74F194 | 4-Bit Bidirectional | 2 | X | | 16 | PC, DC, SC, DM, FM, LM |
| 74F299 | 8-Bit Octal Storage | 2 | X | X | 20 | PC, DC, SC |
| 54F/74F322 | 8-Bit Parallel | 2 | X | X | 20 | PC, DC, SC, DM, FM |
| 74F323 | 8-Bit Storage | 2 | X | X | 20 | PC, DC, SC |
| 74F673A | 16-Bit S/P Out | 1 | | X | 24 | SPC, SDC |
| 74F675A | 16-Bit S/P Out | 1 | | | 24 | SPC, SDC |
| 54F/74F676 | 16-Bit Serial Out | 1 | X | | 24 | SPC, SDC, SDM, FM |

S/P = Serial/Parallel

## Microprocessor Support

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| 74F148 | 8-Line to 3-Line Priority Encoder | 16 | PC, DC, SC |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# FAST (54F/74FXX) (Continued)

## ALUs

| Device | Arithmetic Functions | Logic Functions | Features | Pins | Package Codes |
|---|---|---|---|---|---|
| 54F/74F181 | 16 | 16 | Carry Generate/Propagate Outputs | 24 | SPC, SDC, SDM, FM, LM |
| 74F381 | 3 | 3 | Carry Generate/Propagate Outputs | 20 | PC, DC, SC |
| 74F382 | 3 | 3 | Ripple Carry Expansion | 20 | PC, DC, SC |
| 74F582 | 2 |  | Lookahead and Ripple Carry Expansion | 24 | SPC, SDC |

## ALU Support

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| 74F182 | Carry Lookahead Generator | 16 | PC, DC, SC |
| 74F350 | 4-Bit Shifter | 16 | PC, DC, SC |
| 74F381 | ALU/Function Generator | 20 | PC, DC, SC |
| 74F382 | ALU/Carry Lookahead Generator | 20 | PC, DC, SC |

## Adders/Subtractors

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| 54F/74F283 | Binary Full Adder w/Carry Lookahead | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F385 | Quad Adder/Subtractor w/Master Reset | 20 | PC, DC, SC, DM, FM, LM |
| 54F/74F583 | BCD Full Adder w/Carry Lookahead | 16 | PC, DC, SC, DM, FM, LM |

## Comparators

| Device | Type | No. of Bits | Features | Pins | Package Codes |
|---|---|---|---|---|---|
| 54F/74F521 | Identity | 8 | Expandable | 20 | PC, DC, SC, DM, FM |
| 74F524 | Magnitude OR Complement | 8 | Expandable, Registered | 20 | PC, DC, SC |

## Divider

| Device | Type | Features | Pins | Package Codes |
|---|---|---|---|---|
| 74F525 | 16-Stage Programmable | Crystal Oscillator Circuit | 28 | DC, SC |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# FAST (54F/74FXX) (Continued)

## Buffers/Line Drivers

| Device | No. of Bits | Inverting | Noninverting | Pins | Package Codes |
|---|---|---|---|---|---|
| 74F125 | | | X | 14 | PC, DC, SC |
| 54F/74F240 | 8 | X | | 20 | PC, DC, SC, DM, FM, LM |
| 54F/74F241 | 8 | | X | 20 | PC, DC, SC, DM, FM, LM |
| 54F/74F244 | 8 | | X | 20 | PC, DC, SC, DM, FM, LM |
| 54F/74F365 | | | X | 16 | PC, DC, SC, DM, FM, LM |
| 74F366 | | X | | 16 | PC, DC, SC |
| 74F368 | | X | | 16 | PC, DC, SC |
| 54F/74F540 | | X | | 20 | PC, DC, SC, DM, FM, LM |
| 74F541 | | | X | 20 | PC, DC, SC |
| 54F/74F827 | 10 | | X | 24 | SPC, SDC, SC, DM, FM, LM, PC |
| 54F/74F828 | 10 | X | | 24 | SPC, SDC, SC, DM, FM, LM, PC |

## Transceivers/Registered Transceivers

| Device | Transceivers | Registered | Features | 3-State Outputs | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 54F/74F243 | 4 | | | X | 14 | DC, DM, FM, LM |
| 54F/74F245 | 8 | | | X | 20 | PC, DC, SC, DM, FM, LM |
| 74F543 | 8 | X | | X | 24 | SPC, SDC, SC |
| 54F/74F544 | 8 | X | Inverting | X | 24 | SPC, SDC, DM, SDM, FM |
| 54F/74F545 | 8 | | | X | 20 | PC, DC, SC, DM, FM |
| 74F550 | 8 | X | Status Flags | X | 28 | DC |
| 74F551 | 8 | X | Status Flags, Inverting | X | 28 | DC |
| 74F552 | 8 | X | Parity and Flag | X | 28 | DC |
| 74F588 | 8 | | GPIB Compatible | X | 20 | PC, DC, SC |
| 54F/74F657 | 8 | | Parity | X | 24 | SPC, SC, SDC, SDM, FM, LM |
| 29F52 | 8 | X | | X | 24 | SDC |
| 29F53 | 8 | X | Inverting | X | 24 | SDC |

# FAST (54F/74FXX) (Continued)

## Multiplexers

| Device | Type | Outputs |  | Pins | Package Codes |
|---|---|---|---|---|---|
|  |  | True | Complement |  |  |
| 54F/74F151A | 8-Input | X | X | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F153 | Dual 4-Input | X |  | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F157A | Quad 2-Input | X |  | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F158A | Quad 2-Input |  | X | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F251A | 8-Input | X | X | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F253 | Dual 4-Input | X |  | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F257A | Quad 2-Input | X |  | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F258A | Quad 2-Input |  | X | 16 | PC, DC, SC, DM, FM, LM |
| 74F350 | 4-Input w/Shift | X |  | 16 | PC, DC, SC |
| 54F/74F352 | Dual 4-Input |  | X | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F353 | Dual 4-Input |  | X | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F398 | Quad 2-Port w/Flip-Flop | X | X | 20 | PC, DC, SC, DM, FM, LM |
| 54F/74F399 | Quad 2-Port w/Flip-Flop | X |  | 16 | PC, DC, SC, DM, FM, LM |

## Decoders/Demultiplexers

| Device | Type | 3-State Outputs | Latched Input | Acknowledge Output | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 54F/74F138 | 1-of-8 |  |  |  | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F139 | Dual 1-of-4 |  |  |  | 16 | PC, DC, SC, DM, FM, LM |
| 74F537 | 1-of-10 | X |  |  | 20 | PC, DC, SC |
| 74F538 | 1-of-8 | X |  |  | 20 | PC, DC, SC |
| 74F539 | Dual 1-of-4 | X |  |  | 20 | PC, DC, SC |
| 54F/74F547 | 3-to-8 |  | X | X | 20 | PC, DC, SC, DM, FM, LM |
| 54F/74F548 | 3-to-8 |  |  | X | 20 | PC, DC, SC, DM, FM, LM |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# FAST (54F/74FXX) (Continued)

## Memory

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| 54F/74F189 | 16 × 4 RAM | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F219 | 16 × 4 RAM | 16 | PC, DC, SC, DM, FM, LM |
| 54F/74F403 | 16 × 4 FIFO | 24 | SPC, SDC, SDM, FM, LM |
| 54F/74F413 | 64 × 4 FIFO | 16 | PC, DC, DM |
| 74F433 | 64 × 4 FIFO | 24 | SPC, SDC, SC |

## Memory Support

| Device | Type | Features | Pins | Package Codes |
|---|---|---|---|---|
| 54F/74F407 | Data Access Register | 3-State Outputs | 24 | SPC, SDC, SDM, FM, LM |
| 54F/74F410 | Register Stack | 3-State Outputs | 18 | DC, SC, DM |

## Cyclic Redundancy Checker-Generator

| Device | Polynomial Length | Expandable | Pins | Package Codes |
|---|---|---|---|---|
| 74F401 | 16 | | 14 | PC, DC, SC |
| 54F/74F402 | 64 | X | 16 | PC, DC, SC, DM |

## Parity Generator/Checker

| Device | Features | Pins | Package Codes |
|---|---|---|---|
| 54F/74F280 | Odd/Even Outputs, 9 Bits In | 14 | PC, DC, SC, DM, FM, LM |

## Error Detection and Correction

| Device | Features | Pins | Package Codes |
|---|---|---|---|
| 74F420 | Parallel Error Detection and Correction | 48 | QC |
| 74F632 | 32-Bit Error Detection and Correction | 52 | DC, QC |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# Low Power Schottky (54LS/74LSXX, 96LSXX)

## NAND Gates

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| 54LS/74LS00 | Quad 2-Input | 14 | PC, DC, DM, FM, LM |
| 54LS/74LS03 | Quad 2-Input (OC) | 14 | PC, DC, DM, FM |
| 54LS/74LS04 | Hex Inverter | 14 | PC, DC, DM, FM, LM |
| 54LS/74LS05 | Hex Inverter (OC) | 14 | PC, DM, FM |
| 54LS/74LS10 | Triple 3-Input | 14 | PC, DC, DM, FM, LM |
| 74LS12 | Triple 3-Input | 14 | PC, DC |
| 54LS/74LS13 | Dual 4-Input Schmitt | 14 | PC, DM, FM, LM |
| 54LS/74LS14 | Hex Schmitt Trigger Inverter | 14 | PC, DC, DM, FM, LM |
| 54LS/74LS20 | Dual 4-Input | 14 | PC, DC, DM, FM, LM |
| 54LS22 | Dual 4-Input (OC) | 14 | DM, FM |
| 54LS/74LS26 | Quad 2-Input (12V) | 14 | PC, DC, DM, FM |
| 54LS/74LS30 | 8-Input | 14 | PC, DC, DM, FM, LM |
| 54LS/74LS37 | Quad 2-Input Buffer | 14 | PC, DC, DM, FM, LM |
| 54LS/74LS38 | Quad 2-Input (OC/48 mA) | 14 | PC, DC, DM, FM |
| 54LS/74LS40 | Dual 4-Input Buffer | 14 | PC, DM, FM, LM |
| 74LS132 | Quad 2-Input Schmitt | 14 | PC, DC |
| 54LS/74LS133 | 13-Input | 16 | PC, DC, DM, FM, LM |

## NOR Gates

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| 54LS/74LS02 | Quad 2-Input | 14 | PC, DC, DM, FM, LM |
| 54LS/74LS27 | Triple 3-Input | 14 | PC, DC, DM, FM, LM |
| 54LS/74LS28 | Quad 2-Input | 14 | PC, DM, FM, LM |
| 54LS/74LS33 | Quad 2-Input (OC) | 14 | PC, DM, FM |
| 54LS/74LS260 | Dual 5-Input | 14 | PC, DC, DM, FM, LM |
| 54LS/74LS266 | Quad 2-Input (OC) | 14 | PC, DC, DM, FM |

OC = Open Collector

## AND Gates

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| 54LS/74LS08 | Quad 2-Input | 14 | PC, DC, DM, FM, LM |
| 54LS/74LS09 | Quad 2-Input (OC) | 14 | PC, DM, FM |
| 54LS/74LS11 | Triple 3-Input | 14 | PC, DC, DM, FM, LM |
| 54LS/74LS15 | Triple 3-Input (OC) | 14 | PC, DM, FM |
| 54LS/74LS21 | Dual 4-Input | 14 | PC, DC, DM, FM, LM |

# Low Power Schottky (54LS/74LSXX, 96LSXX) (Continued)

## OR Gates

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| 54LS/74LS32 | Quad 2-Input | 14 | PC, DC, DM, FM, LM |

## Exclusive-OR Gates

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| 74LS86 | Quad 2-Input | 14 | PC, DC |
| 54LS/74LS136 | Quad 2-Input (OC) | 14 | PC, DM, FM |
| 74LS386 | Quad 2-Input | 14 | PC, DC |

## Exclusive-NOR Gates

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| 54LS/74LS266 | Quad 2-Input (OC) | 14 | PC, DC, DM, FM |

OC = Open Collector

## AND/OR-Invert Gates

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| 54LS/74LS51 | Quad 2-2 Input | 14 | PC, DC, DM, FM, LM |
| 54LS/74LS54 | 4-Wide, 2-Input | 14 | PC, DC, DM, FM |
| 54LS/74LS55 | 2-Wide, 4-Input | 14 | PC, DM, FM |

## Buffer Gates and Drivers

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| 54LS/74LS125A | Quad Buffer (3S) | 14 | PC, DC, DM, FM, LM |
| 54LS/74LS126 | Quad Buffer (3S) | 14 | PC, DC, DM, FM |
| 54LS/74LS365A | Hex (3S) | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS366A | Hex Inverter (3S) | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS367A | Hex (3S) | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS368A | Hex Inverter (3S) | 16 | PC, DC, DM, FM, LM |

3S = 3-State

# Low Power Schottky (54LS/74LSXX, 96LSXX) (Continued)

## Single and Dual Flip-Flops

| Device | Type | Inputs | Direct Set | Direct Clear | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|
| 54LS74 | Dual D | D | X | X | 30 | 14 | DM, FM, LM |
| 74LS74A | Dual D | D | X | X | 30 | 14 | PC |
| 54LS109 | Dual JK | J,K | X | X | 30 | 16 | DM, FM |
| 74LS109A | Dual JK | J,K | X | X | 30 | 16 | PC |
| 54LS/74LS112 | Dual JK | J,K | X | X | 30 | 16 | PC, DC, DM, FM, LM |
| 54LS113 | Dual JK | J,K | X | | 30 | 14 | DM, FM, LM |
| 54LS114 | Dual JK | J,K | X | X | 30 | 14 | DM, FM, LM |
| 54LS/74LS174 | Hex D | D | | X | 30 | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS175 | Quad | D | | X | 30 | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS374 | Octal D | D | | | 35 | 20 | PC, DC, DM, FM, LM |
| 54LS/74LS377 | Octal D | D | | | 30 | 20 | PC, DC, DM, FM, LM |
| 74LS574 | Octal D | D | | | 35 | 20 | PC, DC |

## Latches

| Device | Type | Data Inputs | Common Clear | Enable Inputs (Level) | Min. Enable Pulse Width (ns) | Max. Delay Enable to Output (ns) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|---|
| 54LS/74LS170 | 16-Bit D | 4 | | 2 | 25 | 35 | 16 | PC, DM, FM |
| 54LS/74LS256 | Dual 4-Bit Addressable | 8 | L | 2 (L) | 17 | 27 | 16 | PC, DM, FM |
| 54LS/74LS259 | 8-Bit Addressable | 1 | L | 1 (L) | 17 | 27 | 16 | PC, DM, FM, LM |
| 54LS/74LS279 | 4-Bit Set-Reset | 4 | | | | | 16 | PC, DM, FM, LM |
| 74LS373 | 8-Bit D | 8 | | 1 (H) | 15 | 30 | 20 | PC, DC |
| 54LS/74LS375 | 4-Bit D | 4 | | 2 (H) | 20 | 30 | 16 | PC, DC, DM, FM |
| 54LS533 | 8-Bit D | 8 | | 1 (H) | 15 | 30 | 20 | PC, DC |
| 74LS563 | 8-Bit D | 8 | | 1 (H) | 15 | 30 | 20 | PC, DC |
| 74LS573 | 8-Bit D | 8 | | 1 (L) | 15 | 30 | 20 | PC, DC |
| 54LS/74LS670 | 16-Bit D | 4 | | 2 | 25 | 35 | 16 | PC, DC, DM, FM, LM |

## Multiple Flip-Flops

| Device | Type | Data Inputs | Common Clear | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 54LS/74LS174 | 6-Bit D | 6 | L | 30 | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS175 | 4-Bit D | 4 | L | 30 | 16 | PC, DC, DM, FM, LM |
| 54LS74LS374 | 8-Bit D | 8 | | 35 | 20 | PC, DC, DM, FM, LM |
| 74LS534 | 8-Bit D | 8 | | 35 | 20 | PC, DC |
| 74LS564 | 8-Bit D | 8 | | 35 | 20 | PC, DC |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# Low Power Schottky (54LS/74LSXX, 96LSXX) (Continued)

## Multiplexers

| Device | Type | Enable Inputs | Outputs True | Outputs Complement | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 54LS/74LS151 | 8-Input | 1 | X | X | 16 | PC, DM, FM, LM |
| 54LS152 | 8-Input | | | X | 16 | FM |
| 54LS/74LS153 | Dual 4-Input | 2 | X | | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS157 | Quad 2-Input | 1 | X | | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS158 | Quad 2-Input | 1 | | X | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS251 | 8-Input | 1 | 3S | 3S | 16 | PC, DC, DM, FM |
| 54LS/74LS253 | Dual 4-Input | 2 | 3S | | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS257A | Quad 2-Input | 1 | 3S | | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS258A | Quad 2-Input | 1 | | 3S | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS298 | Quad 2-Port | Clock (E-T) | Latched | | 16 | PC, DM, FM |
| 54LS/74LS352 | Dual 4-Input | 2 | | X | 16 | PC, DC, DM, FM |
| 54LS/74LS353 | Dual 4-Input | 2 | | 3S | 16 | PC, DC, DM, FM |

3S = 3-State
E-T = Edge-Trigger

## Decoders/Demultiplexers

| Device | Type | Address Inputs | Active Low Enable | Active Low Outputs | Open Collector Output Voltage (V) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|
| 54LS/74LS42 | 1-of-10 | 4 (BCD) | | 10 | | 16 | PC, DC, DM, FM |
| 54LS/74LS138 | 1-of-8 | 3 | 2 | 8 | | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS139 | Dual 1-of-4 | 2 + 2 | 1 + 1 | 4 + 4 | | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS155 | Dual 1-of-4 | 2 | 2 + 1 | 4 + 4 | | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS156 | Dual 1-of-4 | 2 | 2 + 1 | 4 + 4 | 5.5 | 16 | PC, DM, FM |
| 54LS/74LS259 | 1-of-8 | 3 | 1 | 8 H | | 16 | PC, DC, DM, FM, LM |

# Low Power Schottky (54LS/74LSXX, 96LSXX) (Continued)

## Registers

| Device | Type | No. of Bits | Serial Entry | Parallel Entry No. of Bits | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|
| 54LS/74LS95B | Right/Left Shift | 4 | D | 4S | 30 | 14 | PC, DC, DM, FM |
| 54LS/74LS164 | Serial-In/Parallel-Out Shift | 8 | 2D | | 25 | 14 | PC, DC, DM, FM, LM |
| 54LS/74LS165 | Parallel/Serial-In Serial-Out Shift | 8 | D | 8A | 30 | 16 | PC, DC, DM, FM |
| 54LS/74LS170 | Register File (OC) | 4 × 4 | | 4A | | 16 | PC, DM, FM |
| 54LS/74LS173 | Quad D (3S) | 4 | | 4S | 30 | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS194A | Bidirectional Universal | 4 | DR, DL | 4S | 30 | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS195A | Universal Shift | 4 | J, K | 4S | 30 | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS273 | Octal D | 8 | | 8S | 30 | 20 | PC, DC, DM, FM, LM |
| 54LS/74LS295A | Shift (3S) | 4 | D | 4S | 30 | 14 | PC, DC, DM, FM |
| 54LS/74LS298 | Quad 2-Port | 4 | | 2D (Mux) | 30 | 16 | PC, DM, FM |
| 54LS/74LS299 | Universal Shift/Storage | 8 | DR, DL | 8S | 35 | 20 | PC, DC, DM, FM, LM |
| 54LS/74LS322 | Serial/Parallel (3S) | 8 | 2D | 8S | 35 | 20 | PC, DC, DM, FM |
| 54LS/74LS323 | Universal Shift/Storage | 8 | DR, DL | 8S | 35 | 20 | PC, DC, DM, FM |
| 54LS/74LS378 | Parallel D | 6 | | 6S | 30 | 16 | PC, DM, FM |
| 54LS/74LS379 | Quad D | 4 | | 4S | 30 | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS395 | Parallel Shift Right (3S) | 4 | D | 4S | 30 | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS502 | Successive Approximation | 8 | D | | 15 | 16 | PC, DC, DM, FM |
| 54LS/74LS503 | Successive Approximation | 8 | D | | 15 | 16 | PC, DC, DM, FM |
| 54LS/74LS670 | Register File (3S) | 4 × 4 | | 4A | | 16 | PC, DC, DM, FM, LM |

# Low Power Schottky (54LS/74LSXX, 96LSXX) (Continued)

## Counters

| Device | Type | Modulus | Parallel Entry | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 74LS90 | Decade | 2 × 5 |  | 32 | 14 | PC, DC |
| 74LS93 | Divide-by-16 | 2 × 8 |  | 32 | 14 | PC, DC |
| 54LS/74LS160A | BCD Decade | 10 P | S | 25 | 16 | PC, DM, FM, LM |
| 54LS/74LS161A | Binary | 16 P | S | 25 | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS162A | BCD Decade | 10 P | S | 25 | 16 | PC, DM, FM, LM |
| 54LS/74LS163A | Binary | 16 P | S | 25 | 16 | PC, DM, FM, LM |
| 54LS168 | Up/Down | 10 P | S | 25 | 16 | DM, FM, LM |
| 54LS/74LS169 | Up/Down | 16 P | S | 25 | 16 | PC, DC, DM, FM, LM |
| 74LS190 | Up/Down Decade | 10 | A | 20 | 16 | PC |
| 74LS191 | Up/Down Binary | 16 | A | 20 | 16 | PC, DC |
| 54LS/74LS192 | Up/Down Decade | 10 | A | 30 | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS193 | Up/Down Binary | 16 | A | 30 | 16 | PC, DC, DM, FM, LM |
| 74LS196 | Decade | 2 × 5 | A | 45 | 14 | PC |
| 74LS197 | Binary | 2 × 8 | A | 50 | 14 | PC, DC |
| 74LS290 | BCD Decade | 2 × 5 |  | 32 | 14 | PC, DC |
| 74LS293 | Binary | 2 × 8 |  | 32 | 14 | PC, DC |
| 74LS390 | Dual Decade | 2 × 5 |  | 40 | 16 | PC, DC |
| 74LS393 | Dual Modulo 16 | 2 × 8 |  | 40 | 14 | PC, DC |
| 54LS/74LS490 | Dual Decade | 2 × 5 |  | 40 | 16 | PC, DM, FM |

S = Synchronous
A = Asynchronous

## Display Decoder/Drivers

| Device | Type | Output Current (mA) | Output Voltage (V) | Active High/Low | Ripple Blanking | Pins | Package Codes |
|---|---|---|---|---|---|---|---|
| 54LS/74LS47 | BCD to 7 Segment | 24.0 | 15.0 | L | X | 16 | PC, DC, DM, FM |
| 54LS/74LS48 | BCD to 7 Segment | 1.3 | 5.5 | H | X | 16 | PC, DC, DM, FM |
| 54LS49 | BCD to 7 Segment | 8.0 | 5.5 | H | X | 14 | DM, FM |
| 54LS/74LS247 | BCD to 7 Segment | 24.0 | 15.0 | L | X | 16 | PC, DC, DM, FM |
| 54LS/74LS248 | BCD to 7 Segment | 1.3 | 5.5 | H | X | 16 | PC, DC, DM, FM |
| 54LS/74LS249 | BCD to 7 Segment | 8.0 | 5.5 | H | X | 16 | PC, DC, DM, FM |
| 54LS/74LS347 | BCD to 7 Segment | 24.0 | 7.0 | L | X | 14 | PC, DC, FM |
| 54LS/74LS447 | BCD to 7 Segment | 24.0 | 7.0 | L | X | 16 | PC, DC, DM, FM |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# Low Power Schottky (54LS/74LSXX, 96LSXX) (Continued)

## Monostables (One-Shots)

| Device | Type | Pulse Width Variation (%) vs Temp. | Pulse Width Variation (%) vs. $V_{CC}$ | No. of Inputs Pos. | No. of Inputs Neg. | Min. Output (tw) (ns) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|---|
| 96LS02 | Dual Retriggerable, Resettable | ± 1.0 | ± 0.8 | 1 | 1 | 35 | 16 | PC, DC, DM, FM |

## Line and Bus Drivers/Transceivers/Receivers

| Device | Type | Companion Receiver | $I_{OL}$ (mA) | Min. $I_{OS}$ (mA) | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 54LS/74LS240 | Octal Inverting Bus Driver (3S) | Any TTL | 64 | – 40 | 20 | PC, DC, DM, FM, LM |
| 54LS/74LS241 | Octal Noninverting Bus Driver (3S) | Any TTL | 64 | – 40 | 20 | PC, DC, DM, FM, LM |
| 54LS/74LS244 | Octal Noninverting Bus Driver (3S) | Any TTL | 64 | – 40 | 20 | PC, DC, DM, FM, LM |
| 54LS/74LS245 | Octal Bus Transceiver | Any TTL | 24 | – 40 | 20 | PC, DC, DM, FM, LM |
| 74LS540 | Octal Buffer Line Driver | Any TTL | 64 | – 40 | 20 | PC, DC |

3S = 3-State

## Arithmetic Operators, 4-Bit

| Device | Type | Features | Pins | Package Codes |
|---|---|---|---|---|
| 54LS/74LS83A | Adder | Full Binary 4-Bit with Carry | 16 | PC, DC, DM, FM |
| 54LS/74LS85 | Comparator | 4-Bit Magnitude with Expander | 16 | PC, DC, DM, FM, LM |
| 54LS/74LS181 | Arithmetic-Logic | External Carry Lookahead | 24 | PC, DM, FM |
| 54LS/74LS283 | Adder | Full Binary 4-Bit with Carry | 16 | PC, DC, DM, FM |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# Schottky (54S/74SXX, 93SXX, 96SXX)

## Gates

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| NAND | | | |
| 74S00 | Quad 2-Input | 14 | PC, DC |
| 74S03 | Quad 2-Input (OC) | 14 | PC, DC |
| 74S04 | Hex Inverter | 14 | PC, DC |
| 74S05 | Hex Inverter (OC) | 14 | PC, DC |
| 74S10 | Triple 3-Input | 14 | PC, DC |
| 74S20 | Dual 4-Input | 14 | PC, DC |
| 74S30 | 8-Input | 14 | PC, DC |
| 74S40 | Dual 4-Input Buffer | 14 | PC, DC |
| 74S132 | Quad 2-Input Schmitt | 14 | PC, DC |
| 74S133 | 13-Input | 14 | PC, DC |
| AND | | | |
| 74S08 | Quad 2-Input | 14 | PC, DC |
| 74S11 | Triple 3-Input | 14 | PC, DC |
| NOR | | | |
| 74S02 | Quad 2-Input | 14 | PC, DC |
| OR | | | |
| 74S32 | Quad 2-Input | 14 | PC, DC |
| Exclusive-OR | | | |
| 74S86 | Quad 2-Input | 14 | PC, DC |
| AND/OR-Invert | | | |
| 74S51 | Quad 2-2 Input | 14 | PC, DC |
| 74S64 | 4-2-3-2 Input | 14 | PC, DC |

OC = Open Collector

## Single and Dual Flip-Flops

| Device | Type | Inputs | Direct Set | Direct Clear | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|
| 74S74 | Dual D | D | X | X | 75 | 14 | PC, DC |
| 74S109 | Dual J-K | J, K | X | X | 75 | 16 | PC, DC |
| 74S112 | Dual J-K | J, K | X | X | 80 | 16 | PC, DC |
| 74S174 | Hex D | D | | X | 75 | 16 | PC, DC |
| 74S175 | Quad D | D | | X | 75 | 16 | PC, DC |

# Schottky (54S/74SXX, 93SXX, 96SXX) (Continued)

## Multiple Flip-Flops

| Device | Type | Data Inputs | Common Clear | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 74S174 | 6-Bit D | 6 | L | 75 | 16 | PC, DC |
| 74S175 | 4-Bit D | 4 | L | 75 | 16 | PC, DC |

## Multiplexers

| Device | Type | Enable Inputs | Outputs | | Pins | Package Codes |
|---|---|---|---|---|---|---|
| | | | True | Complement | | |
| 74S151 | 8-Input | 1 | X | X | 16 | PC, DC |
| 74S153 | Dual 4-Input | 2 | X | | 16 | PC, DC |
| 74S157 | Quad 2-Input | 1 | X | | 16 | PC, DC |
| 74S158 | Quad 2-Input | 1 | | X | 16 | PC, DC |
| 74S253 | Dual 4-Input | 2 | 3S | | 16 | PC, DC |
| 74S257 | Quad 2-Input | 1 | 3S | | 16 | PC, DC |
| 74S258 | Quad 2-Input | 1 | | 3S | 16 | PC, DC |

3S = 3-State

## Decoders/Demultiplexers

| Device | Type | Address Inputs | Active Low | | Pins | Package Codes |
|---|---|---|---|---|---|---|
| | | | Enable | Outputs | | |
| 74S138 | 1-of-8 | 3 | 2 | 8 | 16 | PC, DC |
| 74S139 | Dual 1-of-4 | 3 | 2 | 8 | 16 | PC, DC |

## Registers

| Device | Type | No. of Bits | Serial Entry | Parallel Entry No. of Bits | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|
| 74S194 | Bidirectional Universal | 4 | DR, DL | 4S | 70 | 16 | PC, DC |
| 93S00 | Universal Shift | 4 | J, $\overline{K}$ | 4S | 70 | 16 | PC, DC |

# Schottky (54S/74SXX, 93SXX, 96SXX) (Continued)

## Counters

| Device | Type | Modulus | Parallel Entry | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 93S10 | BCD Decade | 10 P | S | 70 | 16 | DC |
| 93S16 | 4-Bit Binary | 16 P | S | 70 | 16 | DC |

S = Synchronous
P = Presettable

## Monostables (One-Shots)

| Device | Type | Pulse Width Variation (%) | | No. of Inputs | | Min. Output (tw) (ns) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|---|
| | | vs. Temp | vs. $V_{CC}$ | Pos. | Neg. | | | |
| 96S02 | Dual Retriggerable, Resettable | ± 1.0 | ± 1.0 | 1 | 1 | 27 | 16 | PC, DC |

## Line and Bus Drivers/Transceivers/Receivers

| Device | Type | Companion Receiver | $I_{OL}$ (mA) | Min. $I_{OS}$ (mA) | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 74S40 | Dual 4-Input NAND Buffer | Any TTL | 60 | – 50 | 14 | PC, DC |

## Arithmetic Operators

| Device | Type | Features | No. of Bits | Pins | Package Codes |
|---|---|---|---|---|---|
| 93S41 | Arithmetic-Logic | External CLA | 4 | 24 | PC, DC |
| 93S43 | Multiplier | Twos Complement | 4 × 2 | 24 | PC, DC |
| 93S46 | Comparator | 6-Bit Identity w/Expander | 6 | 16 | PC, DC |
| 93S47 | Comparator, High-Speed | 6-Bit Identity (OC) | 6 | 16 | PC, DC |
| 93S62 | Parity | 9-Bit Parity Generator/Checker | 9 | 14 | PC, DC |

OC = Open Collector

# Standard TTL (54/74XX, 93XX, 96XX)

## Gates

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| **NAND** | | | |
| 54/7400 | Quad 2-Input | 14 | PC, DC, DM, FM |
| 7401 | Quad 2-Input (OC) | 14 | PC, DC |
| 7403 | Quad 3-Input (OC) | 14 | PC, DC |
| 54/7404 | Hex Inverter | 14 | PC, DC, DM, FM |
| 7405 | Hex Inverter (OC) | 14 | PC, DC |
| 7406 | Hex Inverter (OC/30V) | 14 | PC, DC |
| 54/7410 | Triple 3-Input | 14 | PC, DC, DM, FM |
| 54/7414 | Hex Schmitt Trigger | 14 | PC, DC, DM, FM |
| 7416 | Hex Inverter (OC/15V) | 14 | PC, DC |
| 54/7420 | Dual 4-Input | 14 | PC, DC, DM, FM |
| 54/7430 | 8-Input | 14 | PC, DC, DM, FM |
| 54/7437 | Quad 2-Input Buffer | 14 | PC, DC, DM, FM |
| 7438 | Quad 2-Input (OC/48 mA) | 14 | PC, DC |
| 7439 | Quad 2-Input NAND Buffer (OC) | 14 | DC |
| 54/7440 | Dual 4-Input Buffer | 14 | PC, DC, DM, FM |
| 74132 | Quad 2-Input Schmitt | 14 | PC, DC |
| 96101 | Quad 2-Input NAND Buffer (OC) | 14 | PC, DC |
| **NOR** | | | |
| 54/7402 | Quad 2-Input | 14 | PC, DC, DM, FM |
| 54/7425 | Dual 4-Input w/Strobe | 14 | PC, DC, DM, FM |
| 7427 | Triple 3-Input | 14 | PC, DC |
| **AND** | | | |
| 7407 | Hex Buffer (OC/30V) | 14 | PC, DC |
| 54/7408 | Quad 2-Input | 14 | PC, DC, DM, FM |
| 54/7409 | Quad 2-Input (OC) | 14 | PC, DC, DM, FM |
| 7411 | Triple 3-Input | 14 | PC, DC |
| 7417 | Hex Buffer (OC/15V) | 14 | PC, DC |
| **OR** | | | |
| 54/7432 | Quad 2-Input | 14 | PC, DC, DM, FM |
| **Exclusive-OR** | | | |
| 54/7486 | Quad 2-Input | 14 | PC, DC, DM, FM |
| **AND/OR-Invert** | | | |
| 7450 | Quad 2-2 Input Expandable | 14 | PC, DC |
| 54/7451 | Dual 2-2 Input | 14 | PC, DC, DM, FM |

OC = Open Collector

# Standard TTL (54/74XX, 93XX, 96XX) (Continued)

## Buffer Gates and Drivers

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| 54/74125 | Quad Bus Buffer (3S) | 14 | PC, DC, DM, FM |

3S = 3-State

## Single and Dual Flip-Flops

| Device | Type | Inputs | Direct Set | Direct Clear | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|
| 54/7473 | Dual J-K | J, K |  | X | 15 | 14 | PC, DC, DM, FM |
| 54/7474 | Dual D | D | X | X | 15 | 14 | PC, DC, DM, FM |
| 54/7476 | Dual J-K | J, K | X | X | 15 | 16 | PC, DC, DM, FM |
| 54/74174 | Hex D |  |  |  | 25 | 16 | PC, DC, DM, FM |
| 54/74175 | Quad D |  |  |  | 25 | 16 | PC, DC, DM, FM |

## Latches

| Device | Type | Data Inputs | Common Clear | Enable Inputs (Level) | Min. Enable Pulse Width (ns) | Max. Delay Enable to Output (ns) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|---|
| 54/7475 | 4-Bit D | 4 |  | 2 (H) | 20 | 30 | 16 | PC, DC, DM, FM |
| 54/74170 | 16-Bit D | 4 |  | 2 | 25 | 45 | 16 | PC, DC, DM, FM |
| 54/74279 | 4-Bit RS | 4 |  |  |  |  | 16 | PC, DC, DM, FM |
| 9308 | Dual 4-Bit D | 8 | 2 × L | 2 × 2 AND | 18 | 30 | 24 | PC, DC, DM, FM |
| 9314 | Quad 4-Bit D, RS | 4 | L | 1 (L) | 18 | 24 | 16 | PC, DC, DM, FM |
| 9334 | 8-Bit Addressable | 1 | L | 1 (L) | 17 | 24 | 16 | PC, DC, DM, FM |

## Multiple Flip-Flops

| Device | Type | Data Inputs | Common Clear | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 54/74174 | 6-Bit D | 6 | L | 25 | 16 | PC, DC, DM, FM |
| 54/74175 | 4-Bit D | 4 | L | 25 | 16 | PC, DC, DM, FM |
| 9338 | 8-Bit Multiple Port Register | 1 |  | 27 | 16 | PC, DC, DM, FM |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# Standard TTL (54/74XX, 93XX, 96XX) (Continued)

## Multiplexers

| Device | Type | Enable Inputs | Outputs True | Outputs Complement | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 54/74150 | 16-Input | 1 |  | X | 24 | PC, DC, DM, FM |
| 54/74151A | 8-Input | 1 | X | X | 16 | PC, DC, DM, FM |
| 54/74153 | Dual 4-Input | 2 | X |  | 16 | PC, DC, DM, FM |
| 54/74157 | Quad 2-Input | 1 | X |  | 16 | PC, DC, DM, FM |
| 54298 | Quad 2-Port | Clock (E-T) | Latched |  | 16 | DM, FM |
| 9309 | Dual 4-Input |  | X | X | 16 | PC, DC, DM, FM |
| 9312 | 8-Input | 1 | X | X | 16 | PC, DC, DM, FM |
| 9322 | Quad 2-Input | 1 | X |  | 16 | PC, DC, DM, FM |

E-T = Edge Triggered

## Decoders/Demultiplexers

| Device | Type | Address Inputs | Active Low Enable | Active Low Outputs | OC Output Voltage (V) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|
| 54/7442A | 1-of-10 | 4 (BCD) |  | 10 |  | 16 | PC, DC, DM, FM |
| 7445 | 1-of-10 | 4 (BCD) |  | 10 | 30 | 16 | PC, DC |
| 74145 | 1-of-10 | 4 (BCD) |  | 10 | 15 | 16 | PC, DC |
| 54/74154 | 1-of-16 | 4 | 2 | 16 |  | 24 | PC, DM, FM |
| 74155 | Dual 1-of-4 | 2 | 2 + 1 | 4 + 4 |  | 16 | PC, DC |
| 9301 | 1-of-10 | 4 (BCD) |  | 10 |  | 16 | PC, DC, DM, FM |
| 9311 | 1-of-16 | 4 | 2 | 16 |  | 24 | PC, DC, DM, FM |
| 9321 | Dual 1-of-4 | 2 + 2 | 1 + 1 | 4 + 4 |  | 16 | PC, DC, DM, FM |
| 9334 | 1-of-8 | 3 | 1 | 8 |  | 16 | PC, DC, DM, FM |

# Standard TTL (54/74XX, 93XX, 96XX) (Continued)

## Registers

| Device | Type | No. of Bits | Serial Entry | Parallel Entry No. of Bits | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|
| 54/7495A | Right/Left Shift | 4 | D | 4S | 25 | 14 | PC, DC, DM, FM |
| 54/74164 | Serial-In/Parallel-Out Shift | 8 | 2D | | 25 | 14 | PC, DC, DM, FM |
| 54/74165 | Parallel to Serial Converter | 8 | D | 8A | 25 | 16 | PC, DC, DM, FM |
| 54/74170 | Register File (OC) | 4 × 4 | | 4A | | 16 | PC, DC, DM, FM |
| 54/74173 | Quad D (3S) | 4 | | 4S | 25 | 16 | PC, DC, DM, FM |
| 54298 | Quad 2-Port | 4 | 2D (Multiplexer) | | 30 | 16 | DM, FM |
| 9300 | Universal Shift | 4 | $J, \overline{K}$ | 4S | 30 | 16 | PC, DC, DM, FM |
| 9328 | Shift | 2 × 8 | 2 × 2 D (Multiplexer) | | 20 | 16 | PC, DC, DM, FM |

OC = Open Collector
3S = 3-State

## Counters

| Device | Type | Modulus | Parallel Entry | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 5490 | Decade | 2 × 5 | | 32 | 14 | DM, FM |
| 7490A | Decade | 2 × 5 | | 32 | 14 | PC, DC |
| 7493A | Divide-by-16 | 2 × 8 | | 32 | 14 | PC, DC |
| 54/7497 | Rate Multiplier | 64 | | 25 | 16 | PC, DC, DM, FM |
| 54/74161 | Binary | 16 P | S | 25 | 16 | PC, DC, DM, FM |
| 74163 | Binary | 16 P | S | 25 | 16 | PC, DC |
| 54/74191 | Up/Down Binary | 16 | A | 20 | 16 | PC, DC, DM, FM |
| 74197 | Binary | 2 × 8 P | A | 50 | 14 | PC, DC |
| 9316 | Binary | 16 P | S | 30 | 16 | PC, DC, DM, FM |

A = Asynchronous
S = Synchronous
P = Presettable

# Standard TTL (54/74XX, 93XX, 96XX) (Continued)

## Display Decoder/Drivers

| Device | Type | Output Current (mA) | Output Voltage (V) | Active High/ Low | Ripple Blanking | Blanking Above BCD 9-Input | Pins | Package Codes |
|---|---|---|---|---|---|---|---|---|
| 7445 | 1-of-10 Driver (OC) | 80 | 30.0 | L | | X | 16 | PC, DC |
| 7447A | BCD to 7-Segment (OC) | 40 | 15.0 | L | X | | 16 | PC, DC |
| 74145 | 1-of-10 Driver (OC) | 80 | 15.0 | L | | X | 16 | PC, DC |
| 9368 | 7-Segment LED Driver, Common Cathode | 20 | 1.7 | H | X | | 16 | PC, DC |
| 9370 | 7-Segment LED Driver, Common Anode (OC) | 20 | 1.7 | H | X | | 16 | PC, DC |
| 9374 | 7-Segment LED Driver, Common Anode | 15 | 10.0 | L | X | | 16 | PC, DC |

OC = Open Collector

## Monostables (One-Shots)

| | | Pulse Width Variation (%) | | No. of Inputs | | | | |
|---|---|---|---|---|---|---|---|---|
| Device | Type | vs. Temp | vs. $V_{CC}$ | Pos. | Neg. | Min. Output (tw) (ns) | Pins | Package Codes |
| 54/74121 | Single Non-Retriggerable | ± 0.25 | ± 0.15 | 1 | 2 | 40 | 14 | PC, DC, DM, FM |
| 54122 | Single Retriggerable, Resettable | ± 2.7 | ± 1.0 | 2 | 2 | 45 | 14 | DM, FM |
| 54/74123 | Dual Retriggerable, Resettable | ± 2.7 | ± 1.0 | 1 | 1 | 45 | 16 | PC, DC, DM, FM |
| 9601 | Single Retriggerable | ± 2.7 | ± 1.0 | 2 | 2 | 50 | 14 | PC, DC, DM, FM |
| 9602 | Dual Retriggerable | ± 1.5 | ± 1.5 | 1 | 1 | 72 | 16 | PC, DC, DM, FM |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# Standard TTL (54/74XX, 93XX, 96XX) (Continued)

## Line and Bus Drivers/Transceivers/Receivers

| Device | Type | Companion Receiver | $I_{OL}$ (mA) | Min. $I_{OS}$ (mA) | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 54/7437 | Quad 2 NAND Buffer | Any TTL | 48 | – 20 | 14 | PC, DC, DM, FM |
| 7438 | Quad 2 NAND Buffer (OC) | 96106 | 48 | OC | 14 | PC, DC |
| 54/7440 | Dual 2 NAND Buffer | Any TTL | 48 | – 20 | 14 | PC, DC, DM, FM |
| 96106 | Quad 2 NAND Buffer (OC) | 96106 | 80 | OC | 14 | PC, DC |

OC = Open Collector

## Arithmetic Operators

| Device | Type | Features | No. of Bits | Pins | Package Codes |
|---|---|---|---|---|---|
| 5483A | Adder | Full Binary w/Carry | 4 | 16 | DM, FM |
| 54/7485 | Comparator | Magnitude w/Expander | 4 | 16 | PC, DC, DM, FM |
| 74180 | Parity | Generator/Checker | 8 | 14 | PC, DC |
| 54/74283 | Adder | Full Binary w/Carry | 4 | 16 | PC, DC, DM, FM |
| 9318 | Encoder | Priority w/Expander | 8 | 16 | PC, DC |
| 9324 | Comparator | Magnitude | 5 | 16 | PC, DC, DM, FM |
| 9348 | Parity | Generator/Checker | 12 | 14 | DM, FM |
| 9386 | Comparator | Identity Exclusive-NOR (OC) | 5 | 16 | PC, DC |

OC = Open Collector

# Low Power TTL (93LXX, 96LXX)

## Latches

| Device | Type | Data Inputs | Common Clear | Enable Inputs (Level) | Min. Enable Pulse Width (ns) | Max. Delay Enable to Output (ns) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|---|
| 93L08 | Dual 4-Bit | 8 | 2 × L | 2 × 2 AND | 30 | 45 | 24 | PC, DC, DM, FM |
| 93L14 | 4-Bit RS or D | 4 | L | 1 (L) | 30 | 45 | 16 | PC, DC, DM, FM |
| 93L34 | 8-Bit Addressable | 1 | L | 1 (L) | 26 | 45 | 16 | PC, DC, DM, FM |

## Multiple Flip-Flops

| Device | Type | Data Inputs | CP Inputs (Level) | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 93L38 | 8-Bit Multiple Port Register | 1 | 1 (L) | 14 | 16 | PC, DC, DM, FM |

## Multiplexers

| Device | Type | Enable Inputs | Outputs | | Pins | Package Codes |
|---|---|---|---|---|---|---|
| | | | True | Complement | | |
| 93L12 | 8-Input | 1 | | X | 16 | DM, FM |
| 93L22 | Quad 2-Input | 1 | X | | 16 | DM, FM |

## Decoders/Demultiplexers

| Device | Type | Address Inputs | Active Low | | Pins | Package Codes |
|---|---|---|---|---|---|---|
| | | | Enable | Outputs | | |
| 93L01 | 1-of-10 | 4 (BCD) | | 10 | 16 | DM, FM |
| 93L21 | Dual 1-of-4 | 2 + 2 | 1 + 1 | 4 + 4 | 16 | DM, FM |
| 93L34 | 1-of-8 | 3 | 1 | 8 | 16 | PC, DC, DM, FM |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# Low Power TTL (93LXX, 96LXX) (Continued)

## Registers

| Device | Type | No. of Bits | Serial Entry | Parallel Entry No. of Bits | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|
| 93L00 | Universal Shift | 4 | J, $\overline{K}$ | 4S | 10 | 16 | DM, FM |
| 93L28 | Dual 8-Bit Shift | 2 × 8 | 2 × 2 D (MUX) |  | 5 | 16 | PC, DC, DM, FM |
| 93L38 | Multiport | 8 | D |  | 20 | 16 | PC, DC, DM, FM |

## Counters

| Device | Type | Modulus | Parallel Entry | Guaranteed Clock Frequency (MHz) | Pins | Package Codes |
|---|---|---|---|---|---|---|
| 93L10 | BCD Decade | 10 P | S | 13 | 16 | DM, FM |

S = Synchronous
P = Presettable

## Monostables (One-Shots)

| Device | Type | Pulse Width Variation (%) |  | No. of Inputs |  | Min. Output (tw) (ns) | Pins | Package Codes |
|---|---|---|---|---|---|---|---|---|
|  |  | vs. Temp | vs. $V_{CC}$ | Pos. | Neg. |  |  |  |
| 96L02 | Dual Retriggerable, Resettable | ± 1.6 | ± 1.5 | 1 | 1 | 110 | 16 | PC, DC, DM, FM |

## Arithmetic Operators

| Device | Type | Features | No. of Bits | Pins | Package Codes |
|---|---|---|---|---|---|
| 93L24 | Comparator | Magnitude | 5 | 16 | PC, DC, DM, FM |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# F100K High-Speed ECL (100XXX)

## Gates and Buffers

| Device | Type | No. Inputs/ Gate | Propagation Delay* (ns) | Pins | Package Codes |
|---|---|---|---|---|---|
| F100101 | Triple OR/NOR | 5 | 0.95 | 24 | DC, FC |
| F100102 | Quint OR/NOR | 2 | 0.95 | 24 | DC, FC |
| F100104 | Quint AND/NAND | 2 | 1.40 | 24 | DC, FC |
| F100107 | Quint Exclusive-OR/NOR | 2 | 1.40 | 24 | DC, FC |
| F100117 | Triple 2-Wide OA/OAI | 5 | 2.30 | 24 | DC, FC |
| F100118 | 5-Wide 5, 4, 4, 4, 2, OA/OAI | 19 | 3.00 | 24 | DC, FC |
| F100121 | 9-Bit Inverter | 1 | 1.25 | 24 | DC, FC |
| F100122 | 9-Bit Buffer | 1 | 1.25 | 24 | DC, FC |

*Maximum propagation delay at 25°C in flatpak.

## Flip-Flops/Latches

| Device | Type | Toggle Frequency Propagation Delay* | Pins | Package Codes |
|---|---|---|---|---|
| F100130 | Triple D Latch | 1.50 ns | 24 | DC, FC |
| F100131 | Triple D Flip-Flop | 350 MHz | 24 | DC, FC |
| F100135 | Triple J-K Flip-Flop | 565 MHz | 24 | DC, FC |
| F100150 | Hex D Latch | 1.20 ns | 24 | DC, FC |
| F100151 | Hex D Flip-Flop | 375 MHz | 24 | DC, FC |
| F100175 | Quint 100K/10K Latch | 2.75 ns | 16 | DC, SDC |

*Minimum $f_{MAX}$ for flip-flops; maximum propagation delay for latches.

## Multiplexers/Demultiplexers

| Device | Type | Propagation Delay* (ns) | Pins | Package Codes |
|---|---|---|---|---|
| F100155 | Quad Multiplexer/Latch | 1.65 | 24 | DC, FC |
| F100163 | Dual 8-Input Multiplexer | 1.50 | 24 | DC, FC |
| F100164 | Single 16-Input Multiplexer | 2.15 | 24 | DC, FC |
| F100170 | Dual 1-of-4 or Single 1-of-8 Demultiplexer/Decoder | 2.50 | 24 | DC, FC |
| F100171 | Triple 4-Input Multiplexer | 1.40 | 24 | DC, FC |

*Maximum propagation delay at 25°C in flatpak.

# F100K High-Speed ECL (100XXX) (Continued)

## Line and Bus Drivers/Transceivers/Receivers

| Device | Type | Propagation Delay* (ns) | Pins | Package Codes |
|---|---|---|---|---|
| F100112 | Quad Driver | 1.20 | 24 | DC, FC |
| F100113 | Quad Line Driver | 1.15 | 24 | DC, FC |
| F100114 | Quint Differential Line Receiver | 1.80 | 24 | DC, FC |
| F100123 | Hex Bus Driver | 2.2/4.10 | 24 | DC, FC |
| F100126 | 9-Bit Backplane Driver | 2.55 | 24 | DC, FC |
| F100250 | Quint Line Transceiver | 4.1 | 24 | DC, FC |

*Maximum propagation delay at 25°C in flatpak.

## Shift Registers/Counters

| Device | Type | Shift Frequency** (MHz) | Pins | Package Codes |
|---|---|---|---|---|
| F100136 | 4-Bit Bidirectional Shift Register or Modulo 16 Up/Down Counter | 250 | 24 | DC, FC |
| F100141 | 8-Bit Bidirectional Shift Register | 300 | 24 | DC, FC |
| F100241 | 8-Bit Shift Register | 565 | 24 | DC, FC |

**Minimum $f_{SHIFT}$ at 25°C in flatpak.

## Arithmetic Operators

| Device | Type | Propagation Delay† (ns) | Pins | Package Codes |
|---|---|---|---|---|
| F100156 | Mask-Merge Latch | 1.60 | 24 | DC, FC |
| F100158 | 8-Bit Shift Matrix | 2.50 | 24 | DC, FC |
| F100160 | Dual Parity Checker/Generator | 3.90 | 24 | DC, FC |
| F100165 | Universal Priority Encoder | 3.90 | 24 | DC, FC |
| F100166 | 9-Bit Comparator | 3.30 | 24 | DC, FC |
| F100179 | Carry Lookahead Generator | 2.70 | 24 | DC, FC |
| F100180 | High-Speed 6-Bit Adder | 4.40 | 24 | DC, FC |
| F100181 | 4-Bit Binary/BCD ALU | 6.60 | 24 | DC, FC |
| F100182 | 9-Bit Wallace Tree Adder | 7.00 | 24 | DC, FC |
| F100183 | 2 × 8-Bit Recode Multiplier | 3.60 | 24 | DC, FC |

†Maximum propagation delay at 25°C in flatpak.

# F100K High-Speed ECL (100XXX) (Continued)

## Translators

| Device | Type | Propagation Delay* (ns) | Pins | Package Codes |
|---|---|---|---|---|
| F100124 | Hex TTL-to-ECL | 2.70 | 24 | DC, FC |
| F100125 | Hex ECL-to-TTL | 3.50 | 24 | DC, FC |
| F100128 | ECL/TTL Bidirectional Translator | 3.56 | 24 | DC, FC |

*Maximum propagation delay at 25°C in flatpack.

## Special Functions

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| F100142 | 4 × 4 Content-Addressable Memory | 24 | DC, FC |
| F100145 | 16 × 4 Register File | 24 | DC, FC |
| F100402 | 16 × 4 Register File | 16 | DC, FC |

# F100K High-Speed ECL (100XXX) (Continued)

## F100K ECL Devices Cross-Reference Guide

| Device | Description | Hitachi | Signetics |
|---|---|---|---|
| F100101 | Triple 5-Input OR/NOR Gate | 100101 | 100101 |
| F100102 | Quint 2-Input OR/NOR Gate | 100102 | 100102 |
| F100104 | Quint 2-Input AND/NAND Gate | | |
| F100107 | Quint Exclusive OR/NOR Gate | 100107 | 100107 |
| F100112 | Quad Driver | 100112 | 100112 |
| F100113 | Quad Line Driver | | 100113 |
| F100114 | Quint Line Receiver | 100114 | 100114 |
| F100117 | Triple 2-Wide OA-OAI | 100117 | 100117 |
| F100118 | Triple 5-Wide OA-OAI | 100118 | 100118 |
| F100121 | 9-Bit Inverting Buffer | | |
| F100122 | 9-Bit Buffer | 100122 | 100122 |
| F100123 | Hex Bus Driver | 100123 | 100123 |
| F100124 | Hex TTL-to-ECL Translator | | |
| F100125 | Hex ECL-to-TTL Translator | 100125 | |
| F100126 | 9-Bit Backplane Driver | 100126 | 100126 |
| F100128 | ECL/TTL Bidirectional Translator | | |
| F100130 | Triple D Latch | 100130 | |
| F100131 | Triple D Flip-Flop | 100131 | 100131 |
| F100135 | Triple J-K Flip-Flop | 100135 | 100135 |
| F100136 | 4-Bit Shift Register/Counter | 100136 | 100136 |
| F100141 | 8-Bit Shift Register | 100141 | 100141 |
| F100142 | 4 × 4 Content-Addressable Memory | 100142 | |
| F100145 | 16 × 4 Register File | | |
| F100150 | Hex D Latch | 100150 | 100150 |
| F100151 | Hex D Flip-Flop | 100151 | 100151 |
| F100155 | Quad Multiplexer/Latch | 100155 | 100155 |
| F100156 | Mask-Merge Latch | 100156 | |
| F100158 | 8-Bit Shift Matrix | 100158 | 100158 |
| F100160 | Dual Parity Generator/Checker | 100160 | 100160 |
| F100163 | Dual 8-Bit Multiplexer | 100163 | 100163 |
| F100164 | 16-Input Multiplexer | 100164 | 100164 |
| F100165 | Priority Encoder | 100165 | 100165 |
| F100166 | 9-Bit Comparator | 100166 | 100166 |
| F100170 | Universal Decoder/Demultiplexer | 100170 | 100170 |
| F100171 | Triple 4-Input Multiplexer | 100171 | 100171 |
| F100175 | Quint 100K/10K Latch | | 100175 |
| F100179 | Carry Lookahead Generator | 100179 | |
| F100180 | High-Speed 6-Bit Adder | | 100180 |
| F100181 | 4-Bit ALU | 100181 | |
| F100182 | 9-Bit Wallace Tree Adder | 100182 | 100182 |
| F100183 | 2 × 8-Bit Multiplier | 100183 | |
| F100241 | 8-Bit Shift Register | | |
| F100250 | Quint Line Transceiver | | |
| F100402 | 16 × 4 Register File | | |

# F11C ECL (11CXX)

## 11C (11CXX)

| Device | Type | Complementary Outputs | Pins | Package Codes |
|---|---|---|---|---|
| 11C01 | Dual 5-4 Input OR/NOR Gate | X | 16 | DC, FC |
| 11C05 | 1 GHz Divide-by-4 Counter | X | 14 | DC, DM |
| 11C06 | 750 MHz D-Type Flip-Flop | X | 16 | DC, FC |
| 11C70 | Master/Slave D-Type Flip-Flop | X | 16 | DC |
| 11C90 | 650 MHz Prescaler | X | 16 | DC, DM |
| 11C91 | 650 MHz Prescaler | X | 16 | DC, DM |

# Fairchild Video Graphics (FVGXXX)

## Video Graphics

| Device | Type | Pins | Package Codes |
|---|---|---|---|
| FVG101 | Triple 8-Bit DAC (CMOS Process) | 40 | DC |
| FVG108 | Single 8-Bit DAC (Bipolar Process) | 24 | DC, FC |
| FVG450 | Triple 4-Bit RAMDAC™ (CMOS Process) | 28 | DC |
| FVG451* | Triple 8-Bit 256 × 12 RAMDAC (CMOS Process) | 84 | CPGA |
| FVG453 | Triple 8-Bit 256 × 24 RAMDAC (CMOS Process) | 40 | DC |
| FVG458* | Triple 8-Bit 256 × 24 RAMDAC (CMOS Process) | 84 | CPGA |

Note: Product is available for purchase but is not explicitly manufactured in Fairchild facilities.

*Please consult your local National Semiconductor Representative to confirm product availability.

# Memory

For additional Memory products, see pages 113 and 437.

# Memory

The Fairchild memory product line provides multiple technologies (ECL, TTL, CMOS) as well as a selection of volatile and nonvolatile memory alternatives.

## ECL

The ECL SRAM product line is targeted to provide very high speeds at industry standard densities for cache, scratchpad, control, and buffer storage applications. Selections are available as fast as 10 ns and as large as 16K. Fairchild's ECL PROMs are designed for high-speed control, mapping, code conversion, and logic replacement. These PROMs feature a typical access time of 12 ns and a decrease in power dissipation with increase in temperature.

## BiCMOS

BiCMOS technology's SRAMs combine a CMOS array with ECL decoding and I/O circuitry, giving the advantages of high speed, good drive capability, and low power at high densities.

## TTL

In TTL, there is a wide selection of both SRAMs and PROMs. RAMs are available in 1-bit, 4-bit, and 9-bit architectures designed for applications ranging from high-speed cache, control, and buffer storage to scratchpad and small buffers. The PROM family includes popular densities up to 64K bits and access times as fast as 35 ns. Fairchild's Isoplanar-Z PROMs use a vertical fuse processing that eliminates surface fuses to achieve higher densities. This family has the lowest power requirements in the industry.

Both families offer products with full military processing and multiple package configurations.

## CMOS

The CMOS SRAM family includes the 64K × 1 standard high-speed 45 ns version and the new data-retention version. This family is also available in military versions and multiple package choices.

### Memory Part Numbering System

XXXXX X X X X

Special Variations
QB = MIL-STD-883 Level B
QR = Commercial Device w/160-Hour Burn-In or Equivalent

Temperature Range
C = 0°C to + 75°C
M = − 55°C to + 125°C

Package Code
P = Plastic DIP
PS = Plastic SIP
PZ = Plastic ZIP
D = Ceramic DIP
CZ = Ceramic ZIP
F = Flatpack
L = Ceramic Leadless Chip Carrier (LCC)
SD = Slim DIP

Speed Grade
Blank = Standard Speed
A = "A" Grade

Device Type

# ECL Memory

## Bipolar Static RAMs (ECL I/O)

| Device | Type | Max. $t_{AA}$ (ns) | Max. $I_{EE}$[1] (mA) | Pins | Package Codes |
|---|---|---|---|---|---|
| F10145A | 16 × 4 Reg. File | 9 | – 150 | 16 | DC, FC |
| F100145 | 16 × 4 Reg. File | 7 | – 247 | 24 | DC, FC, LC |
| F10402 | 16 × 4 Reg. File | 5 | – 170 | 16 | DC, FC |
| F100402 | 16 × 4 Reg. File | 5 | – 170 | 16 | DC[2], FC |
| F10415 | 1024 × 1 | 10 | – 200 | 16 | DC, FC |
| F100415 | 1024 × 1 | 10 | – 200 | 16 | DC, FC |
| F10422 | 256 × 4 | 5, 7, 10 | – 230, – 200, – 230 | 24 | DC, FC |
| F100422 | 256 × 4 | 5, 7, 10 | – 230, – 200, – 230 | 24 | DC[2], FC |
| F10474 | 1024 × 4 | 10 | – 225 | 24 | DC, FC |
| F100474 | 1024 × 4 | 10 | – 225 | 24 | DC, FC |
| F10545A | 16 × 4 Reg. File | 9 | – 150 | 16 | DC, FC |

Note 1: Most negative value.
Note 2: Choice of CERDIP or side-braze DIP.

## ECL SRAMs Cross-Reference Guide

| Fairchild | Type | $t_{AA}$ (ns) | AMD | Fujitsu | Hitachi | Motorola | National | Signetics |
|---|---|---|---|---|---|---|---|---|
| F10145A | 16 × 4 | 9 | | | HD10145 | MCM10145 | | |
| F100145 | 16 × 4 | 9 | | | HD100145 | | | 100145 |
| F10402 | 16 × 4 | 6 | | | | MCM10H145 | | |
| F100402 | 16 × 4 | 6 | | | | | | |
| F10415 | 1K × 1 | 10 | AM10415 | MBM10415 | HD10415 | | DM10415 | 10415 |
| F100415 | 1K × 1 | 10 | AM100415 | MBM100415 | HD100415 | | | 100415 |
| F10422 | 256 × 4 | 10 | | MBM10422 | HD10422 | | DM10422 | 10422 |
| F100422 | 256 × 4 | 10 | | MBM100422 | HD100422 | | | 100422 |

# BiCMOS Memory

## BiCMOS Static RAMs (ECL I/O) $V_{EE} = -5.0V \pm 10\%$

| Device | Type | Max. $t_{AA}$ (ns) | Max. $I_{EE}$ (mA) | Pins | Package Codes |
|---|---|---|---|---|---|
| NM4490 | 64K × 1 | 12 | 180 | 22 | DC, FC |
| NM4490 | | 15 | | | DM, FM |
| NM4494 | 16K × 4 | 12 | 200 | 28 | DC, FC |
| NM4494 | | 15 | | | DM, FM |
| NM5100 | 256K × 1 | 15 | 180 | 24 | DC, FC |
| NM5100 | | 17 | | | DM, FM |
| NM5400 | 64K × 4 | 15 | 200 | 28 | DC, FC |
| NM5400 | | 17 | | | DM, FM |

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# TTL Memory

## Bipolar Static RAMs (TTL I/O)

| Device | Type | Max.<br>$t_{AA}$ (ns) | Max.<br>$I_{CC}$ (mA) | Pins | Package Codes |
|---|---|---|---|---|---|
| F93415[2] | 1024 × 1 OC | 20, 25, 45 | 65, 125, 155 | 16 | PC, DC[1], FC |
| F93415 | | 25, 30, 40, 60 | 75, 135, 170 | | DM[1], FM |
| F93415A[2] | 1024 × 1 OC | 30 | 155 | 16 | PC, DC[1], FC |
| F93L415[2] | 1024 × 1 OC | 35, 45, 60 | 65, 65, 65 | 16 | PC, DC[1], FC |
| F93L415 | | 50, 70 | 75, 75 | | DM[1], FM |
| F93422[3] | 256 × 43S | 25, 45 | 80, 120 | 16 | PC, DC[1], FC, LC |
| F93422 | | 30, 60 | 90, 130 | | DM[1], FM, LM |
| F93422A[3] | 256 × 4 3S | 35 | 120 | 16 | PC, DC[1], FC, LC |
| F93422A | | 45 | 130 | | DM[1], FM, LM |
| F93L422[3] | 256 × 4 3S | 60 | 80 | 16 | PC, DC[1], FC, LC |
| F93L422 | | 75 | 90 | | DM[1], FM, LM |
| F93L422A[3] | 256 × 4 3S | 45 | 80 | 16 | PC, DC[1], FC, LC |
| F93L422A | | 55 | 90 | | DM[1], FM, LM |
| F93425[3] | 1024 × 1 3S | 20, 25, 45 | 65, 125, 155 | 16 | PC, DC[1], FC, LC |
| F93425 | | 25, 30, 40, 60 | 90, 135, 135, 170 | | DM[1], FM, LM |
| F93425A[3] | 1024 × 1 3S | 30 | 155 | 16 | PC, DC[1], FC, LC |
| F93L425[3] | 1024 × 1 3S | 35, 45, 60 | 65, 65, 65 | 16 | PC, DC[1], FC, LC |
| F93L425 | | 40, 50, 70 | 75, 75, 75 | | DM[1], FM, LM |
| F93479[3] | 256 × 9 3S | 45 | 185 | 16 | PC, DC[1], LC |
| F93479 | | 60 | 200 | | DM[1], FM, LM |
| F93479A[3] | 256 × 9 3S | 35 | 185 | 16 | PC, DC[1], LC |
| F93479A | | 45 | 200 | | DM[1], FM, LM |

Note 1: Choice of CERDIP or side-braze DIP.
Note 2: Open collector.
Note 3: 3-state.

## TTL SRAMs Cross-Reference Guide

| Fairchild | Type | $t_{AA}$(ns) | AMD | Cypress | Intel | Motorola | Signetics |
|---|---|---|---|---|---|---|---|
| F93415 | 1K × 1 | 25/30 | AM93415 | | 2125 | MCM93415 | |
| F93L415 | 1K × 1 | 35/45 | | | | | |
| F93425 | 1K × 1 | 25/30 | AM93425 | | 2125 | MCM93425 | |
| F93L425 | 1K × 1 | 35/45 | AM93L425 | | | | |
| F93422 | 256 × 4 | 35/45 | AM93422 | CYC122 | | MCM93422 | |
| F93L422 | 256 × 4 | 45/60 | AM93L422 | CYC122 | | MCM93L422 | |
| F93479 | 256 × 9 | 35/45 | | | | | S82S212 |

Note: This cross-reference guide lists devices that are equivalent in speed and functions. The data is based on competitive claims. Not all devices are available.

# TTL Memory (Continued)

## Bipolar PROMs (TTL I/O)

| Device | Type | Max. $t_{AA}$ (ns) | Max. $I_{CC}$ (mA) | Pins | Package Codes |
|---|---|---|---|---|---|
| F93Z451 | 1024 × 8 3S | 40 | 135 | 24/8 | PC, DC[1], SDC, FC, LC |
| F93Z451 | | 55 | 135 | | DM[1], SDM, FM, LM |
| F93Z451A | 1024 × 8 3S | 35 | 135 | 24/8 | PC, DC[1], SDC, FC, LC |
| F93Z451A | | 45 | 135 | | DM[1], SDM, FM, LM |
| F93Z511 | 2048 × 8 3S | 45 | 175 | 24/8 | PC, DC[1], SDC, FC, LC |
| F93Z511 | | 55 | 175 | | DM[1], SDM, FM, LM |
| F93Z565 | 8196 × 8 3S | 55 | 180 | 24/8 | DC[2], LC |
| F93Z565 | | 65 | 180 | | DM[2], LM |
| F93Z565A | 8196 × 8 3S | 45 | 180 | 24/8 | DC[2], LC |
| F93Z565A | | 55 | 180 | | DM[2], LM |
| F93Z665 | 8196 × 8 3S | 35, 40, 45, 50 | 180, 180, 180 | 24/8 | DC[2], LC |
| F93Z665 | | 45, 50, 55 | 185, 185, 185 | | DM[2], LM |
| F93Z667 | 8196 × 8 3S | 35, 40, 45, 50 | 180, 180, 180 | 24 | DC[3] |
| F93Z667 | | 45, 50, 55 | 185, 185, 185 | | DM[3] |

**Note 1:** Choice of CERDIP or side-braze DIP.
**Note 2:** 600-mil side-braze DIP.
**Note 3:** 300-mil side-braze DIP.

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# TTL Memory (Continued)

## TTL PROMs Cross-Reference Guide

| Fairchild | Type | $t_{AA}$ (ns) | AMD | Cypress | Fujitsu | Hitachi | IXICOR | MMI | Motorola | National | NEC | Raytheon | Signetics | TI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F93Z451 | 1K × 8 | 35/40 | AM27S181 | | MB7132 | HN25089 | | 53/6381 | MCM7681 | DM87S181 | uBP417 | 29631 | N82S181 | TBP28S86 |
| F93Z451 | 1K × 8 | 35/40 | AM27S281 | | MB7132SK | | | | | DM87S281 | | | | TBP28S86 |
| F93Z511 | 2K × 8 | 45 | AM27S191 | CY7C245 | MB7138 | HN25169 | | 63S1681 | MCM76161 | DM87S191 | uBP429 | 29681 | N82S191 | TBP38L166 |
| F93Z511 | 2K × 8 | 45 | AM27S291 | | MB7138SK | | | | | DM87S291 | | | N82S191 | |
| F93Z565 | 8K × 8 | 45/55 | AM27S49 | | MB7144 | | | | | | | | N82S641 | |
| F93Z665 | 8K × 8 | 35 | | CY7C264 | | | | | | | | | | |
| F93Z667[1] | 8K × 8 | 35 | | CY7C264 | | | | | | | | | | |
| F93Z665 | 8K × 8 | 40 | AM27S49 | CY7C264 | | | X2664 | | | | | | | |
| F93Z667[1] | 8K × 8 | 40 | AM27S49 | CY7C264 | | | X2664 | | | | | | | |
| F93Z665 | 8K × 8 | 45 | AM27S49 | CY7C264 | MB7144 | | | 53/6356481A | | | | | H82HS641A | |
| F93Z667[1] | 8K × 8 | 45 | AM27S49 | CY7C264 | MB7144 | | | 53/6356481A | | | | | | |
| F93Z665 | 8K × 8 | 50 | | CY7C264 | MB7144 | | | | | | | | | |
| F93Z667[1] | 8K × 8 | 50 | | CY7C264 | MB7144 | | | | | | | | | |

Note 1: Slim Line Package

This cross-reference guide lists devices that are equivalent in both speed and functions. The data is based on competitive claims. Not all devices are available.

For additional information on aerospace and defense products, please refer to the Aerospace and Defense section of this Guide (Page 355), or contact your National Sales Representative.

# CMOS Memory

## CMOS Static RAMs (TTL I/O)

| Device | Type | Max. $t_{AA}$ (ns) | Max. $I_{CC}$ (mA) | Max. $I_{CCDR}$ ($\mu$A) | Pins | Package Codes |
|---|---|---|---|---|---|---|
| F1600A | 64K × 1 | 25, 35, 45 | 90, 80, 70 | | 22 | DC[1], LC |
| F1600A | | 30, 35, 45, 55 | 90, 80, 70 | | | DM[1], LM |
| F1601A | 64K × 1 DR[2] | 25, 35, 45 | 90, 80, 70 | 50 | 22 | DC[1], LC |
| F1601A | | 30, 35, 45, 55 | 90, 80, 70 | 200 | | DM[1], LM |
| F1620 | 16K × 4 | 25, 35, 45 | 100, 90, 80 | | 22 | DC[1], LC |
| F1620 | | 30, 35, 45, 55 | 100, 90, 80 | | | DM[1], LM |
| F1621 | 16K × 4 DR | 25, 35, 45 | 100, 90, 80 | 50 | 22 | DC[1], LC |
| F1621 | | 30, 35, 45, 55 | 100, 90, 80 | 200 | | DM[1], LM |
| F1624 | 16K × 4 OE[3] | 25, 35, 45 | 100, 90, 80 | | 24/8 | DC[1], LC |
| F1624 | | 30, 35, 45, 55 | 100, 90, 80 | | | DM[1], LM |
| F1625 | 16K × 4 OE and DR | 25, 35, 45 | 100, 90, 80 | 50 | 24/8 | DC[1], LC |
| F1625 | | 30, 35, 45, 55 | 100, 90, 80 | 200 | | DM[1], LM |

**Note 1:** 600-mil side-braze DIP.
**Note 2:** DR = data retention.
**Note 3:** OE = open emitter.

# CMOS Memory (Continued)

## CMOS Static RAMs Cross-Reference Guide

| Fairchild | Type | $t_{AA}$ (ns) | AMD | Cypress | Fujitsu | Hitachi | Hyundai | INMOS | IDT | Lattice | Mitsubishi | Motorola | NEC | Performance | VLSI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F1600A | 64K × 1 | 25 | AM99C641 | CY7C187 | MB81C71A | HM6787 |  |  | IDT7187 | SR764K1 | M5M5187A | MCM6287 |  | P4C187 |  |
| F1600A |  | 35 | AM99C641 | CY7C187 | MB81C71A |  | HY62C87 |  | IDT7187 | SR764K1 | M5M5187A | MCM6287 |  |  |  |
| F1600A |  | 45 | AM99C641 | CY7C187 | MB81C71 |  | HY62C87 | IMS1600 | IDT7187 | SR764K1 | M5M5187 | MCM6287 | uPD4361 |  |  |
| F1601A | 64K × 1 | 25 | AM99C641 |  |  |  |  |  | IDT7187L |  |  |  |  |  |  |
| F1601A |  | 35 | AM99C641 |  |  |  |  |  | IDT7187L |  |  |  |  |  |  |
| F1601A |  | 45 | AM99C641 |  |  |  |  |  | IDT7187L |  |  |  |  |  |  |
| F1620 | 16K × 4 | 25 |  | CY7C164 | MB81C74 |  |  |  | IDT7188 |  | M5M5188A | MCM6288 |  | P4C188 | VT64KS4 |
| F1620 |  | 35 | AM99C164 | CY7C164 | MB81C74 | HM6788 | HY62C88 |  | IDT7188 |  | M5M5188A | MCM6288 |  | P4C188 | VT64KS4 |
| F1620 |  | 45 | AM99C164 | CY7C164 |  |  | HY62C88 |  | IDT7188 |  | M5M5188 | MCM6288 | uPD4362 |  | VT64KS4 |
| F1621 | 16K × 4 | 25 |  |  |  |  |  |  | IDT7188L |  |  |  |  |  |  |
| F1621 |  | 35 | AM99C164 |  |  |  |  |  | IDT7188L |  |  |  |  |  |  |
| F1621 |  | 45 | AM99C164 |  |  |  |  |  | IDT7188L |  |  |  |  |  |  |
| F1624 | 16K × 4 | 25 |  | CY7C166 | MB81C75 |  |  |  | IDT7198 |  |  |  |  |  | VT65KS4 |
| F1624 |  | 35 | AM99C165 | CY7C166 | MB81C75 |  |  |  | IDT7198 | SR64K4 |  |  |  |  | VT65KS4 |
| F1624 |  | 45 | AM99C164 | CY7C166 |  |  |  | IMS1624 | IDT7198 | SR64K4 | M5M5188 |  |  |  |  |
| F1625 | 16K × 4 | 25 |  |  |  |  |  |  | IDT7198L |  |  |  |  |  |  |
| F1625 |  | 35 | AM99C165 |  |  |  |  |  | IDT7198L |  |  |  |  |  |  |
| F1625 |  | 45 | AM99C165 |  |  |  |  |  | IDT7198L |  |  |  |  |  |  |

This cross-reference guide lists devices that are equivalent in both speed and functions. The data is based on competitive claims. Not all devices are available.

# Microprocessors

For additional Microprocessor products, see pages 141 and 451.

# 16-Bit Microprocessors

Fairchild's focus is on high-performance embedded controller applications based on the F9450 16-bit microprocessor. These applications are typically driven by a fixed program. The controller is incorporated within a system that surrounds it, making its functions largely invisible to the outside world.

The F9450 is a monolithic implementation of the MIL-STD-1750A instruction set architecture, mandated for use in many military applications. All F9450s pass the U.S. Air Force SEAFAC VSW test, Version 2.1 + 2, and all military-grade products fully comply with the requirements of MIL-STD-883C and Military Drawing 84169.

The attraction of the F9450 in the commercial market is its raw speed and fast context switching, its on-chip floating-point capability, and its interrupt and fault handling capabilities. Current designs include graphics workstations.

Various support tools are available for the F9450. Training seminars and programming courses are available from both Fairchild and major suppliers of development systems and software. To assist in your software development efforts, Fairchild provides MACRO-50, a macro-assembler for the F9450. In addition, a development board, the SRC50, is available to aid in hardware and software integration.

Third party support for the F9450 includes Ada, JOVIAL, FORTRAN and CMS-2 compilers. Ada, JOVIAL and CMS-2 compilers are available from DoD as well as mainstream software houses. Both Tektronix and Hewlett Packard provide in-system emulation and debug support for F9450 based systems.

## F9445

The F9445 microprocessor, a 16-bit device that exercises a Fairchild superset of the NOVA® instruction set, can address up to 64K words of memory, directly address 62 I/O devices, handle 16 levels of priority interrupt, and perform fast direct memory access. The F9445's sophisticated pipeline architecture is combined with Fairchild's bipolar Isoplanar Integrated Injection Logic ($I^3L$®) to provide very fast execution times.

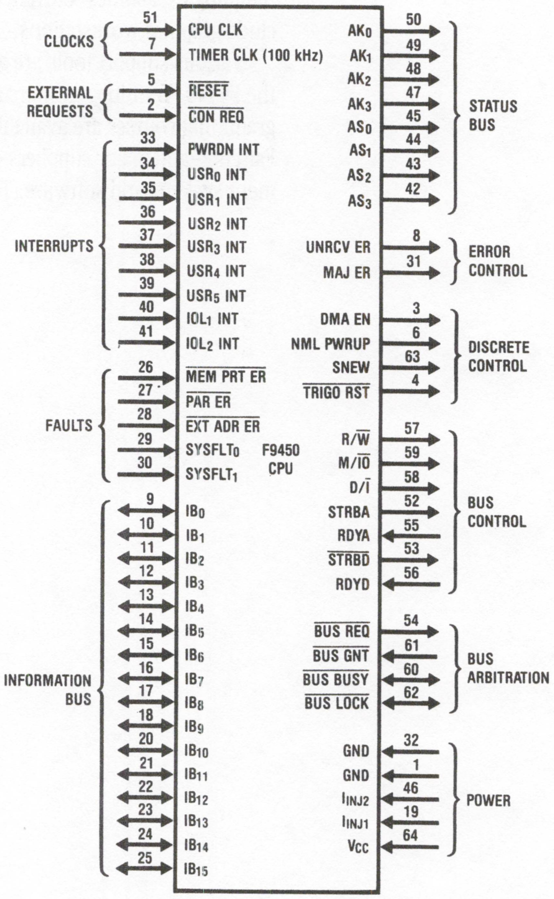
# F9450 High-Performance 16-Bit Bipolar Microprocessor MIL-STD-1750A

## General Description

The Fairchild F9450 microprocessor is the nucleus of a family of high-performance devices intended for commercial and military applications requiring sophisticated, high-speed, real-time processing. The F9450 executes the complete requirements of MIL-STD-1750A and has passed the Air Force MIL-STD-1750A compliance certification test. It has, on-chip, all of the functions necessary to perform floating-point operations without the use of a coprocessor. Other on-chip capabilities allow addressing of up to 2M words of memory and, with the addition of the optional F9451 Memory Management Unit (MMU), up to 16M words of memory.

Real-time processing is achieved through advanced architecture that incorporates two programmable timers, user-accessible general-purpose registers, a complete 16-level interrupt processor, and a comprehensive fault handler on the chip. Multiprocessing is supported by a flexible bus arbitration scheme, as well as process synchronization (test and set) instruction.

### Signal Functions


CLOCKS
51 CPU CLK
7 TIMER CLK (100 kHz)
EXTERNAL REQUESTS
5 RESET
2 CON REQ
INTERRUPTS
33 PWRDN INT
34 USR0 INT
35 USR1 INT
36 USR2 INT
37 USR3 INT
38 USR4 INT
39 USR5 INT
40 IOL1 INT
41 IOL2 INT
FAULTS
26 MEM PRT ER
27 PAR ER
28 EXT ADR ER
29 SYSFLT0
30 SYSFLT1
INFORMATION BUS
9 IB0
10 IB1
11 IB2
12 IB3
13 IB4
14 IB5
15 IB6
16 IB7
17 IB8
18 IB9
20 IB10
21 IB11
22 IB12
23 IB13
24 IB14
25 IB15
F9450 CPU
AK0 50
AK1 49
AK2 48
AK3 47
AS0 45
AS1 44
AS2 43
AS3 42
STATUS BUS
UNRCV ER 8
MAJ ER 31
ERROR CONTROL
DMA EN 3
NML PWRUP 6
SNEW 63
TRIGO RST 4
DISCRETE CONTROL
R/W 57
M/IO 59
D/I 58
STRBA 52
RDYA 55
STRBD 53
RDYD 56
BUS CONTROL
BUS REQ 54
BUS GNT 61
BUS BUSY 60
BUS LOCK 62
BUS ARBITRATION
GND 32
GND 1
IINJ2 46
IINJ1 19
VCC 64
POWER

## Features

- Single-chip 16-bit microprocessor with 32- and 48-bit floating-point arithmetic on-chip
- Real-time processing: two programmable timers, 16 levels of vectored interrupt
- Address space of up to 2M words, expandable to 16M words with optional F9451
- Instruction set optimized for real-time applications (MIL-STD-1750A ISA)
- Built-in self-test, fault handling, and abort
- Twenty-four user-accessible registers
- Built-in multiprocessor capabilities
- Single- and double-precision integer arithmetic
- Built in console operations
- Complete high-level language and design development support available
- Static operation with single 0–20 MHz clock
- TTL inputs and outputs with 8 mA drive capability
- Small-size 64-pin DIP or optional surface-mount packages
- Full performance over − 55°C to + 125°C operating temperature range
- Bipolar $I^3L$ technology
- Fully compliant with MIL-STD-883C requirements
- Available as DESC Drawing 84169

The F9450 family of support circuits and systems provides additional capabilities. These include memory-mapped expansion with the F9451 Memory Management Unit and write protection with the F9452 Block Protect Unit. The F9454 Memory Interface Unit also provides for memory expansion, as well as access protection for instruction and data space. The F9455 System Integration Unit furnishes basic functions necessary for implementing board-level systems with 64K words of memory or less, based on the F9450.

Comprehensive software support for the F9450, including assemblers, loaders, simulators, and compilers, is provided by Fairchild and other sources. Software development for the F9450 can be performed on VAX/VMS systems.

# F9451 Memory Management Unit MIL-STD-1750A

## General Description

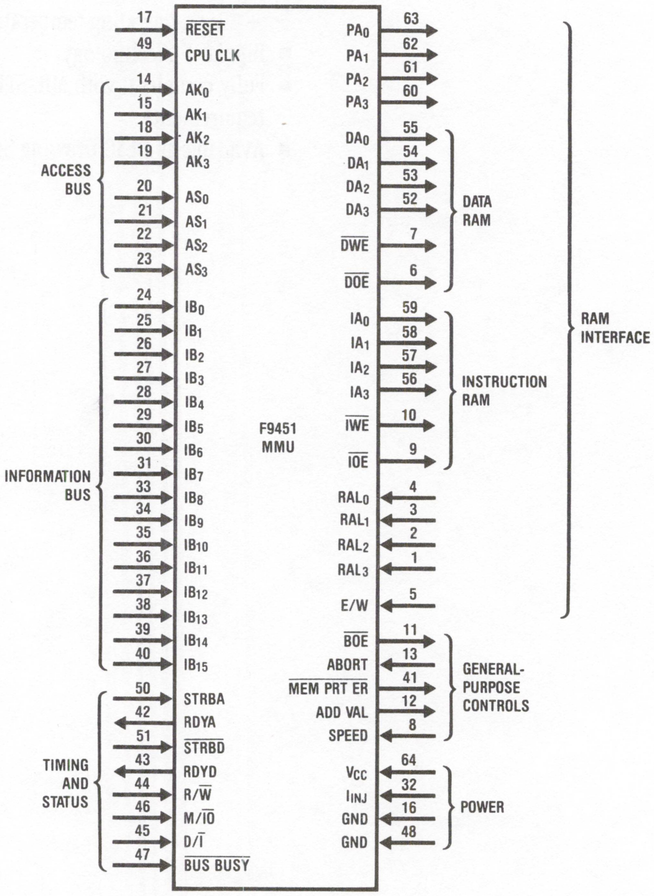
The F9451 Memory Management Unit (MMU) controller provides facilities to expand the memory addressing range of the F9450 CPU up to 16M words of physical memory and provides access protection mechanisms for instructions and data. The MMU subsystem consists of the F9451 controller together with four F93479 or equivalent static RAMs (SRAMs), used as instruction and data maps, and two octal buffers (54/74F245).

The MMU chip set works with the F9450, either by itself or together with the F9452 Block Protect Unit (BPU), to implement MIL-STD-1750A memory management and protection functions.

## Features

- Allows up to 1M words of memory address space as specified by MIL-STD-1750A
- Logical-to-physical address translation
- Protection of the logical space in 4K word pages for:
  - — access key to access lock match
  - — write protect (data)
  - — execute protect (instructions)
- On-chip cache mechanism
- Two translation maps
  - — instruction map (256 × 16)
  - — data map (256 × 16)
- High performance over military temperature range
- Static operation with single 0–20 MHz clock
- TTL-compatible inputs and outputs
- 64-pin DIP or surface mount
- Bipolar LSI $I^3L$ technology

### Signal Functions


17 RESET
49 CPU CLK
ACCESS BUS
14 AK0
15 AK1
18 AK2
19 AK3
20 AS0
21 AS1
22 AS2
23 AS3
INFORMATION BUS
24 IB0
25 IB1
26 IB2
27 IB3
28 IB4
29 IB5
30 IB6
31 IB7
33 IB8
34 IB9
35 IB10
36 IB11
37 IB12
38 IB13
39 IB14
40 IB15
TIMING AND STATUS
50 STRBA
42 RDYA
51 STRBD
43 RDYD
44 R/W
46 M/IO
45 D/I
47 BUS BUSY
F9451 MMU
PA0 63
PA1 62
PA2 61
PA3 60
DA0 55
DA1 54
DA2 53
DA3 52
DWE 7
DOE 6
DATA RAM
IA0 59
IA1 58
IA2 57
IA3 56
IWE 10
IOE 9
INSTRUCTION RAM
RAL0 4
RAL1 3
RAL2 2
RAL3 1
E/W 5
RAM INTERFACE
BOE 11
ABORT 13
MEM PRT ER 41
ADD VAL 12
SPEED 8
GENERAL-PURPOSE CONTROLS
Vcc 64
IINJ 32
GND 16
GND 48
POWER

# F9452 Block Protect Unit MIL-STD-1750A

## General Description

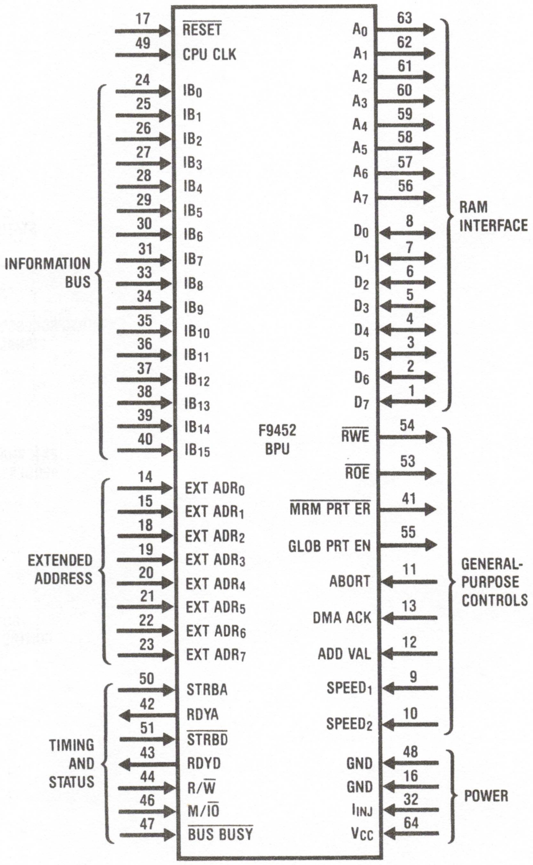
The Fairchild F9452 Block Protect Unit (BPU) controller provides write protection for up to 1M word of physical memory for both CPU and DMA access in systems using the F9450 CPU. The BPU chip set works with the F9450 microprocessor, either by itself or together with the F9451 Memory Management Unit (MMU) to implement MIL-STD-1750A memory block protection functions.

A complete BPU consists of the F9452 controller and one F93479 or equivalent static RAM (SRAM) that is used for storage of CPU and DMA protection tables. Separate tables are maintained for CPU and DMA memory spaces. Global write protection is provided from reset until memory writes are enabled.

## Features

- Write protection of physical CPU and DMA memory space
- Protection of 1K pages
- Global memory protection from initialization/reset to enable
- High performance over military temperature range
- Static operation with single 0–20 MHz clock
- TTL-compatible inputs and outputs
- 64-pin DIP or surface mount
- Bipolar LSI I$^3$L technology

**Signal Functions**



17 RESET
49 CPU CLK
INFORMATION BUS
24 IB0
25 IB1
26 IB2
27 IB3
28 IB4
29 IB5
30 IB6
31 IB7
33 IB8
34 IB9
35 IB10
36 IB11
37 IB12
38 IB13
39 IB14
40 IB15
EXTENDED ADDRESS
14 EXT ADR0
15 EXT ADR1
18 EXT ADR2
19 EXT ADR3
20 EXT ADR4
21 EXT ADR5
22 EXT ADR6
23 EXT ADR7
TIMING AND STATUS
50 STRBA
42 RDYA
51 STRBD
43 RDYD
44 R/W
46 M/IO
47 BUS BUSY
F9452 BPU
RAM INTERFACE
A0 63
A1 62
A2 61
A3 60
A4 59
A5 58
A6 57
A7 56
D0 8
D1 7
D2 6
D3 5
D4 4
D5 3
D6 2
D7 1
GENERAL-PURPOSE CONTROLS
RWE 54
ROE 53
MRM PRT ER 41
GLOB PRT EN 55
ABORT 11
DMA ACK 13
ADD VAL 12
SPEED1 9
SPEED2 10
POWER
GND 48
GND 16
IINJ 32
VCC 64

# F9445 16-Bit Bipolar Microprocessor

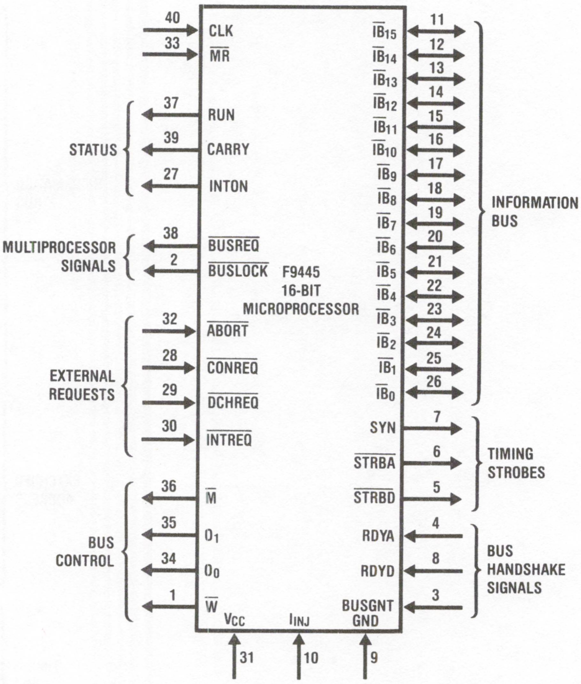
## General Description

The F9445 is a 16-bit microprocessor implemented using Fairchild's Isoplanar Integrated Injection Logic ($I^3L$) technology. This bipolar technology and sophisticated pipeline architecture combine to give the F9445 very fast execution times. The processor has eight program-accessible registers and the capability of directly addressing 128K bytes (64K words) of memory. The F9445 can address 62 I/O devices, handle 16 levels of priority interrupt, and perform fast direct memory access. It has control lines to provide operator-console functions and has an on-chip self-test program.

## Features

- Advanced parallel architecture leading to very fast execution times—250 ns register, 2.9 μs 16 × 16 bit multiply
- Directly addresses up to 128K bytes of memory with 11 addressing modes
- Eight program-accessible registers (AC0, AC1, AC2, AC3, SP, FP, PC, PSW)
- Versatile instruction set including memory reference, ALU, I/O, stack, multiply/divide, and floating-point assist (scale/normalize) instructions with 8-bit byte, 16-bit word, or 32-bit double-word data
- Multiprocessing capabilities
- Flexible operator-control functions and self-test
- Static operation with single clock up to 24 MHz
- LS TTL input/output structure with $I^3L$ internal circuits
- 40-Pin DIP needing a single + 5V power supply
- Full military temperature and voltage ranges
- Radiation-tolerant technology

### Signal Functions


40
CLK
33
$\overline{MR}$
37
RUN
39
CARRY
27
INTON
STATUS
38
$\overline{BUSREQ}$
2
$\overline{BUSLOCK}$
MULTIPROCESSOR SIGNALS
F9445 16-BIT MICROPROCESSOR
32
$\overline{ABORT}$
28
$\overline{CONREQ}$
29
$\overline{DCHREQ}$
30
$\overline{INTREQ}$
EXTERNAL REQUESTS
36
$\overline{M}$
35
$O_1$
34
$O_0$
1
$\overline{W}$
BUS CONTROL
$V_{CC}$
31
$I_{INJ}$
10
GND
9
11
$\overline{IB}_{15}$
12
$\overline{IB}_{14}$
13
$\overline{IB}_{13}$
14
$\overline{IB}_{12}$
15
$\overline{IB}_{11}$
16
$\overline{IB}_{10}$
17
$\overline{IB}_9$
18
$\overline{IB}_8$
19
$\overline{IB}_7$
20
$\overline{IB}_6$
21
$\overline{IB}_5$
22
$\overline{IB}_4$
23
$\overline{IB}_3$
24
$\overline{IB}_2$
25
$\overline{IB}_1$
26
$\overline{IB}_0$
INFORMATION BUS
7
SYN
6
$\overline{STRBA}$
5
$\overline{STRBD}$
TIMING STROBES
4
RDYA
8
RDYD
3
BUSGNT
BUS HANDSHAKE SIGNALS

# Power & Discrete

# Power and Discrete

Fairchild's power and discrete products meet the needs of the consumer, industrial, computer, telecommunications, and high-reliability industries. Many of the devices are available in surface-mount packages, including leadless diodes (LL), small-outline transistors (SOT), and small-outline integrated circuits (SOIC).

The discrete devices include small signal switching and zener diodes in hermetic glass packages, and monolithic diode arrays in both plastic and ceramic packages. General-purpose and switching bipolar transistors are available in plastic and hermetic metal can packages, as well as plastic quad transistor arrays and plastic photo-transistors.

The power devices are designed to offer special advantages in switching power supply applications. The full spec, full voltage MOSFET line has over 250 products, with more in development. In addition to industry standard types, Fairchild offers COOLFETs™, featuring a lower $r_{DS(on)}$ for greater efficiency and reliability and lower power loss. A growing line of JANTX and JANTXV MOSFETs meets the requirements of high-reliability applications.

Fairchild also offers ultrafast power rectifiers. Available in both single- and dual-chip configurations, these rectifiers have the lowest forward voltage drop in the industry, ensuring low power loss, and their soft recovery minimizes any noise generation. All power products are available in both TO-220 plastic and TO-3 hermetic metal can packaging. New TO-247 plastic packages will be available shortly. All power devices are also available in die and wafer form (for more information, consult the factory).

Other power devices in development reflect Fairchild's commitment to providing the power conversion system market with the leading edge in semiconductor technology. These products include higher cell density power MOSFETs, insulated gate devices, improved control circuits, high-power integrated circuits, and lower cost packages displaying improved thermal characteristics.

# Small Signal Diodes

## Small Signal Diodes (DO-35 Package)

BA128
BA130
BA216
BA217
BA218
BAV17
BAV18
BAV19
BAV20
BAV21
BAX13

BAX16
BAY71
BAY72
BAY73
BAY74
BAY80
FDH300
FDH333
FDH400
FDH444
FDH600
FDH666

FDH900
FDH999
FDH1000
1N456
1N456A
1N457
1N457A
1N458
1N458A
1N459
1N459A
1N461A

1N462A
1N463A
1N482B
1N483B
1N484B
1N485B
1N625
1N626
1N627
1N628
1N629
1N658

1N659
1N660
1N661
1N914
1N914A
1N914B
1N916
1N916A
1N916B
1N3064
1N3070
1N3595

1N3600
1N4009
1N4148
1N4149
1N4150
1N4151
1N4152
1N4153
1N4154
1N4305
1N4446
1N4447

1N4448
1N4449
1N4450
1N4454
1N4938
1N5282
1N6099
1S44
1S920
1S921
1S922
1S923

## Small Signal Diodes (DO-7 Package)

BAY82

FD700

FD777

FJT1100

1N4376

## Zener Diodes (DO-35 and DO-41 Packages)

1N746A
1N747A
1N748A
1N749A
1N750A
1N751A
1N752A
1N753A
1N754A
1N755A
1N756A
1N757A
1N758A

1N759A
1N957B
1N958B
1N959B
1N960B
1N961B
1N962B
1N963B
1N964B
1N965B
1N966B
1N967B
1N968B

1N969B
1N970B
1N971B
1N972B
1N973B
1N4728A
1N4729A
1N4730A
1N4731A
1N4732A
1N4733A
1N4734A
1N4735A

1N4736A
1N4737A
1N4738A
1N4739A
1N4740A
1N4741A
1N4742A
1N4743A
1N4744A
1N4745A
1N4746A
1N4747A
1N4748A

1N4749A
1N4750A
1N4751A
1N4752A
1N5226B
1N5227B
1N5228B
1N5229B
1N5230B
1N5231B
1N5232B
1N5233B

1N5234B
1N5235B
1N5236B
1N5237B
1N5238B
1N5239B
1N5240B
1N5241B
1N5242B
1N5243B
1N5244B
1N5245B

1N5246B
1N5247B
1N5248B
1N5249B
1N5250B
1N5251B
1N5252B
1N5253B
1N5254B
1N5255B
1N5256B
1N5257B

## Leadless Small Signal Diodes (LL-34 Package)

FDLL300
FDLL333
FDLL400
FDLL444
FDLL456
FDLL456A
FDLL457
FDLL457A
FDLL458

FDLL458A
FDLL459
FDLL459A
FDLL461A
FDLL462A
FDLL463A
FDLL482B
FDLL483B
FDLL484B

FDLL485B
FDLL600
FDLL625
FDLL626
FDLL627
FDLL628
FDLL629
FDLL658
FDLL659

FDLL660
FDLL661
FDLL666
FDLL700
FDLL777
FDLL914
FDLL914A
FDLL914B
FDLL916

FDLL916A
FDLL916B
FDLL920
FDLL921
FDLL922
FDLL923
FDLL1000
FDLL3064
FDLL3070

FDLL3595
FDLL3600
FDLL4009
FDLL4148
FDLL4149
FDLL4150
FDLL4151
FDLL4152
FDLL4153

FDLL4154
FDLL4305
FDLL4446
FDLL4447
FDLL4448
FDLL4449
FDLL4450
FDLL4454
FDLL6099

# Small Signal Diodes (Continued)

## Surface-Mount Small Signal Diodes (SOT-23 Package) (TO-236AA/AB)

BAS16
BAV70
BAV74
BAV99
BAW56
FDS01201
FDS01202
FDS01203
FDS01204
FDS01205
FDS01401
FDS01402
FDS01403
FDS01404
FDS01405
FDS01501
FDS01502
FDS01503
FDS01504
FDS01505
FDS01701
FDS01702
FDS01703
FDS01704
FDS01705

## Monolithic Diode Arrays (Plastic-Metal-Ceramic Packages)

FSA1410M
FSA1411M
FSA2002M
FSA2003M
FSA2502M
FSA2503M
FSA2503P
FSA2504M
FSA2510M
FSA2510P
FSA2563M
FSA2563P
FSA2565M
FSA2565P
FSA2566M
FSA2566P
FSA2620M
FSA2620P
FSA2621M
FSA2702M
FSA2705M
FSA2719M
FSA2719P
FSA2720M
1N5768
1N5770
1N5772
1N5774

FSA2500M
FSA2501M
FSA2501P
FSA2509M
FSA2509P
FSA2564M
FSA2564P
FSA2619M
FSA2619P
FSA2703M
FSA2704M
FSA2720P
FSA2721M
1N6100
1N6101

## Surface-Mount Monolithic Diode Arrays (SOIC Package)

FAS02501
FAS02503
FAS02509
FAS02510
FAS02563
FAS02564
FAS02565
FAS02566
FAS02618
FAS02619
FAS02620
FAS02718
FAS02719
FAS02720
FAS05768
FAS05770
FAS05772
FAS05774
FAS06101

# Small Signal Transistors

## Small Signal Transistors (TO-92 Package)

MPS706
MPS706A
MPS918
MPS2369
MPS2924
MPS3392
MPS3393
MPS3563
MPS3639
MPS3640
MPS3646
MPS3702
MPS3703
MPS3704
MPS3705
MPS4355
MPS4356
MPS5172
MPS6514
MPS6515
MPS6518
MPS6520
MPS6521

MPS6535M
MPS6560
MPS6561
MPS6562
MPS6571
MPSA05
MPSA06
MPSA10
MPSA12
MPSA13
MPSA14
MPSA18
MPSA20
MPSA42
MPSA43
MPSA55
MPSA56
MPSA70
MPSA92
MPSA93
MPSL01
MPSL51
PE4010

PE4020
PE7058
PE7059
PE8050
PE8050B
PE8550
PN918
PN930
PN2218
PN2218A
PN2219
PN2219A
PN2221
PN2221A
PN2222
PN2222A
PN2484
PN2904
PN2904A
PN2905
PN2905A
PN2906
PN2906A

PN2907
PN2907A
PN3251
PN3563
PN3565
PN3566
PN3567
PN3569
PN3638
PN3638A
PN3639
PN3640
PN3641
PN3642
PN3643
PN3644
PN3645
PN3646
PN3693
PN3694
PN4121
PN4122
PN4248

PN4249
PN4250
PN4250A
PN4258
PN4274
PN4275
PN4354
PN4355
PN4356
PN4888
PN4889
PN4916
PN4917
PN5128
PN5130
PN5133
PN5134
PN5135
PN5136
PN5137
PN5138
PN5139
PN5142

PN5143
PN5770
PN5855
PN5857
PN5965
2N697
2N706
2N3903
2N3904
2N3905
2N3906
2N4123
2N4124
2N4125
2N4126
2N4400
2N4401
2N4402
2N4403
2N4409
2N4410
2N5086
2N5087

2N5088
2N5089
2N5209
2N5210
2N5220
2N5223
2N5224
2N5225
2N5226
2N5227
2N5228
2N5400
2N5401
2N5550
2N5551
2N5769
2N5771
2N5772
2N5830
2N5831
2N5833
2N5961
2N5962

## Small Signal Transistors (TO-18 Package)

2N930
2N930A
2N2221
2N2221A

2N2222
2N2222A
2N2369
2N2369A

2N2484
2N2586
2N2710
2N22906

2N2906A
2N2907
2N2907A

2N3117
2N3700
2N3701

2N3946
2N3962
2N4013

2N4014
2N4208
2N4209

## Small Signal Transistors (TO-39 Package)

2N697
2N1132
2N1132A
2N1613
2N1890
2N1893
2N2218
2N2218A

2N2219
2N2219A
2N2270
2N2405
2N2904
2N2904A
2N2905
2N2905A

2N3019
2N3020
2N3053
2N3107
2N3108
2N3109
2N3253
2N3439

2N3440
2N3724
2N3725
2N4030
2N4031
2N4032
2N4033
2N4036

2N4037
2N4234
2N4235
2N4236
2N4237
2N4238
2N4239
2N4896

2N5320
2N5321
2N5322
2N5323
2N5336
2N5338
2N5415
2N5416

2N5679
2N5680
2N5681
2N5682

# Small Signal Transistors (Continued)

## Quad Transistors (TO-116 Package)

FPQ2222
FPQ2907
FPQ3724
FPQ3725
FPQ3904
FPQ3906
FPQ6426
FPQ6502
FPQ6700

## Surface-Mount Quad Transistors (SOIC Package)

FQS02222
FQS02907
FQS03724
FQS03725
FQS03904
FQS03906
FQS06426
FQS06502
FQS06700

## Surface-Mount Transistors (SOT-23 Package) (TO-236AA/AB)

BCF29
BCF30
BCF70
BCF81

BCW29
BCW30
BCW32
BCW33

BCW60A
BCW61A
BCW65A
BCW66F

BCW69
BCW70
BCW72
BCW81

BCX70G
BCX70H
BCX70J
BCX71H

BCX71J
BCX71K
BSR13
BSR14

BSR15
BSR16
BSR17

BSS63
BSS64
BSS79B
BSS79C

BSS80B
BSS80C
BSV52
BSX39

FTS0697
FTS0706
FTS0706A
FTS0918

FTS0930
FTS0930A
FTS02218
FTS02218A

FTS02219
FTS02219A
FTS02221
FTS02221A

FTS0222
FTS0222A
FTS02369
FTS02369A

FTS02484
FTS02586
FTS02170

FTS02904
FTS02904A
FTS02905
FTS02905A

FTS02906
FTS02906A
FTS02907
FTS02907A

FTS02924
FTS03013
FTS03014
FTS03117

FTS03251
FTS03392
FTS03393
FTS03563

FTS03565
FTS03566
FTS03569
FTS03638

FTS03638A
FTS03639
FTS03640
FTS03641

FTS03642
FTS03643
FTS03644

FTS03645
FTS03646
FTS03693
FTS03694

FTS03702
FTS03703
FTS03704
FTS03705

FTS03903
FTS03904
FTS03905
FTS03906

FTS03946
FTS03962
FTS04036
FTS04037

FTS04121
FTS04122
FTS04123
FTS04124

FTS04125
FTS04126
FTS04208
FTS04209

FTS04248
FTS04249
FTS04250

FTS04250A
FTS04258
FTS04274
FTS04275

FTS04354
FTS04355
FTS04356
FTS04400

FTS04401
FTS04402
FTS04403
FTS04409

FTS04410
FTS04888
FTS04889
FTS04916

FTS04917
FTS05086
FTS05087
FTS05088

FTS05089
FTS05128
FTS05130
FTS05133

FTS05134
FTS05135
FTS05136

FTS05137
FTS05138
FTS05139
FTS05142

FTS05143
FTS05172
FTS05209
FTS05210

FTS05220
FTS05223
FTS05224
FTS05225

FTS05226
FTS05227
FTS05228
FTS05400

FTS05401
FTS05550
FTS05551
FTS05769

FTS05771
FTS05772
FTS05830
FTS05831

FTS05833
FTS05855
FTS05857

FTS05961
FTS05962
FTS05965
FTS06514

FTS06515
FTS06518
FTS06520
FTS06521

FTS06560
FTS06561
FTS06562
FTS06571

FTS0A05
FTS0A06
FTS0A13
FTS0A14

FTS0A20
FTS0A42
FTS0A43
FTS0A55

FTS0A56
FTS0A70
FTS0A92
FTS0A93

FTS0L01
FTS0L51

# Power Electronic Components

## Metal Packages (TO-204AA/TO-204AE)

| Device | $V_{DSS}$ (V) | $I_{DR}$ (A) | $r_{DS\,(on)}$ ($\Omega$) | Package Types |
|---|---|---|---|---|
| IRF450CF | 500 | 14.5 | 0.320 | TO-204AA |
| IRF450 | 500 | 13.0 | 0.400 | TO-204AA |
| 2N6770 | 500 | 12.0 | 0.400 | TO-204AE |
| IRF452 | 500 | 12.0 | 0.500 | TO-204AA |
| MTM7N50 | 500 | 7.0 | 0.800 | TO-204AA |
| IRF440 | 500 | 8.0 | 0.850 | TO-204AA |
| IRF442 | 500 | 7.0 | 1.100 | TO-204AA |
| IRF430 | 500 | 4.5 | 1.500 | TO-204AA |
| MTM4N50 | 500 | 4.0 | 1.500 | TO-204AA |
| 2N6762 | 500 | 4.5 | 1.500 | TO-204AA |
| IRF432 | 500 | 4.0 | 2.000 | TO-204AA |
| IRF420 | 500 | 2.5 | 3.000 | TO-204AA |
| IRF422 | 500 | 2.0 | 4.000 | TO-204AA |
| IRF451 | 450 | 13.0 | 0.400 | TO-204AA |
| IRF453 | 450 | 12.0 | 0.500 | TO-204AA |
| 2N6769 | 450 | 11.0 | 0.500 | TO-204AA |
| MTM7N45 | 450 | 7.0 | 0.800 | TO-204AA |
| IRF441 | 450 | 8.0 | 0.850 | TO-204AA |
| IRF443 | 450 | 7.0 | 1.100 | TO-204AA |
| IRF431 | 450 | 4.5 | 1.500 | TO-204AA |
| MTM7N45 | 450 | 4.0 | 1.500 | TO-204AA |
| IRF433 | 450 | 4.0 | 2.000 | TO-204AA |
| 2N6761 | 450 | 4.0 | 2.000 | TO-204AA |
| IRF421 | 450 | 2.5 | 3.000 | TO-204AA |
| IRF423 | 450 | 2.0 | 4.000 | TO-204AA |
| IRF350CF | 400 | 16.8 | 0.240 | TO-204AA |
| IRF350 | 400 | 15.0 | 0.300 | TO-204AA |
| IRF352 | 400 | 13.0 | 0.400 | TO-204AA |
| 2N6768 | 400 | 14.0 | 0.300 | TO-204AE |
| MTM8N40 | 400 | 8.0 | 0.550 | TO-204AA |
| IRF340 | 400 | 10.0 | 0.550 | TO-204AA |
| IRF342 | 400 | 8.0 | 0.800 | TO-204AA |
| IRF330 | 400 | 5.5 | 1.000 | TO-204AA |
| 2N6760 | 400 | 5.5 | 1.000 | TO-204AA |
| MTM5N40 | 400 | 5.0 | 1.000 | TO-204AA |
| IRF332 | 400 | 4.5 | 1.500 | TO-204AA |
| IRF320 | 400 | 3.0 | 1.800 | TO-204AA |
| IRF322 | 400 | 2.5 | 2.500 | TO-204AA |

# Power Electronic Components (Continued)

## Metal Packages (TO-204AA/TO-204AE) (Continued)

| Device | $V_{DSS}$ (V) | $I_{DR}$ (A) | $r_{DS\,(on)}$ (Ω) | Package Types |
|---|---|---|---|---|
| IRF351 | 350 | 15.0 | 0.300 | TO-204AA |
| IRF353 | 350 | 13.0 | 0.400 | TO-204AA |
| 2N6767 | 350 | 12.0 | 0.400 | TO-204AA |
| IRF341 | 350 | 10.0 | 0.550 | TO-204AA |
| MTM8N35 | 350 | 8.0 | 0.550 | TO-204AA |
| IRF343 | 350 | 8.0 | 0.800 | TO-204AA |
| IRF331 | 350 | 5.5 | 1.000 | TO-204AA |
| MTM5N35 | 350 | 5.0 | 1.000 | TO-204AA |
| IRF333 | 350 | 4.5 | 1.500 | TO-204AA |
| 2N6759 | 350 | 4.5 | 1.500 | TO-204AA |
| IRF321 | 350 | 3.0 | 1.800 | TO-204AA |
| IRF323 | 350 | 2.5 | 2.500 | TO-204AA |
| IRF250CF | 200 | 33.0 | 0.068 | TO-204AE |
| 2N6766 | 200 | 30.0 | 0.085 | TO-204AE |
| IRF250 | 200 | 30.0 | 0.085 | TO-204AA |
| IRF252 | 200 | 25.0 | 0.120 | TO-204AA |
| IRF240 | 200 | 18.0 | 0.180 | TO-204AE |
| IRF242 | 200 | 16.0 | 0.220 | TO-204AE |
| 2N6758 | 200 | 9.0 | 0.400 | TO-204AA |
| IRF230 | 200 | 9.0 | 0.400 | TO-204AA |
| IRF232 | 200 | 8.0 | 0.600 | TO-204AA |
| IRF220 | 200 | 5.0 | 0.800 | TO-204AA |
| IRF222 | 200 | 4.0 | 1.200 | TO-204AA |
| IRF251 | 150 | 30.0 | 0.085 | TO-204AA |
| 2N6765 | 150 | 25.0 | 0.120 | TO-204AA |
| IRF253 | 150 | 25.0 | 0.120 | TO-204AA |
| IRF241 | 150 | 18.0 | 0.180 | TO-204AE |
| IRF243 | 150 | 16.0 | 0.220 | TO-204AE |
| IRF231 | 150 | 9.0 | 0.400 | TO-204AA |
| IRF233 | 150 | 8.0 | 0.600 | TO-204AA |
| 2N6757 | 150 | 8.0 | 0.600 | TO-204AA |
| IRF221 | 150 | 5.0 | 0.800 | TO-204AA |
| IRF223 | 150 | 4.0 | 1.200 | TO-204AA |

# Power Electronic Components (Continued)

## Metal Packages (TO-204AA/TO-204AE) (Continued)

| Device | $V_{DSS}$ (V) | $I_{DR}$ (A) | $r_{DS\,(on)}$ (Ω) | Package Types |
|---|---|---|---|---|
| IRF150CF | 100 | 44.0 | 0.044 | TO-204AE |
| IRF150 | 100 | 40.0 | 0.055 | TO-204AE |
| 2N6764 | 100 | 38.0 | 0.055 | TO-204AE |
| IRF152 | 100 | 33.0 | 0.080 | TO-204AE |
| IRF140 | 100 | 27.0 | 0.085 | TO-204AE |
| IRF142 | 100 | 24.0 | 0.110 | TO-204AE |
| 2N6756 | 100 | 14.0 | 0.180 | TO-204AA |
| IRF130 | 100 | 14.0 | 0.180 | TO-204AA |
| IRF132 | 100 | 12.0 | 0.250 | TO-204AA |
| IRF120 | 100 | 8.0 | 0.300 | TO-204AA |
| IRF122 | 100 | 7.0 | 0.400 | TO-204AA |
| IRF151 | 60 | 40.0 | 0.055 | TO-204AE |
| 2N6763 | 60 | 40.0 | 0.055 | TO-204AE |
| IRF153 | 60 | 33.0 | 0.080 | TO-204AE |
| IRF141 | 60 | 27.0 | 0.085 | TO-204AE |
| IRF143 | 60 | 24.0 | 0.110 | TO-204AE |
| IRF131 | 60 | 14.0 | 0.180 | TO-204AA |
| 2N6755 | 60 | 12.0 | 0.250 | TO-204AE |
| IRF133 | 60 | 12.0 | 0.250 | TO-204AA |
| IRF121 | 60 | 8.0 | 0.300 | TO-204AA |
| IRF123 | 60 | 7.0 | 0.400 | TO-204AA |

## Plastic Encapsulated Packages (TO-220AB/TO-3P)

| Device | $V_{DSS}$ (V) | $I_{DR}$ (A) | $r_{DS\,(on)}$ (Ω) | Package Types |
|---|---|---|---|---|
| IRFP450CF | 500 | 15.5 | 0.320 | TO-3P |
| IRFP450 | 500 | 14.0 | 0.400 | TO-3P |
| IRF840CF | 500 | 8.9 | 0.680 | TO-220AB |
| IRFP440CF | 500 | 10.5 | 0.680 | TO-3P |
| IRF840 | 500 | 8.0 | 0.850 | TO-220AB |
| IRFP440 | 500 | 8.8 | 0.850 | TO-3P |
| IRF842 | 500 | 7.0 | 1.100 | TO-220AB |
| IRF830CF | 500 | 5.0 | 1.200 | TO-220AB |
| IRF830 | 500 | 4.5 | 1.500 | TO-220AB |
| MTP4N50 | 500 | 4.0 | 1.500 | TO-220AB |
| IRF832 | 500 | 4.0 | 2.000 | TO-220AB |
| IRF820CF | 500 | 2.8 | 2.400 | TO-220AB |
| IRF820 | 500 | 2.5 | 3.000 | TO-220AB |
| IRF822 | 500 | 2.0 | 4.000 | TO-220AB |
| MTP2N50 | 500 | 3.0 | 4.000 | TO-220AB |

# Power Electronic Components (Continued)

## Plastic Encapsulated Packages (TO-220AB/TO-3P) (Continued)

| Device | $V_{DSS}$ (V) | $I_{DR}$ (A) | $r_{DS\,(on)}$ (Ω) | Package Types |
|---|---|---|---|---|
| IRFP451CF | 450 | 15.5 | 0.320 | TO-3P |
| IRFP451 | 450 | 14.0 | 0.400 | TO-3P |
| IRFP441CF | 450 | 10.5 | 0.680 | TO-3P |
| IRF841 | 450 | 8.0 | 0.850 | TO-220AB |
| IRFP441 | 450 | 8.8 | 0.850 | TO-3P |
| IRF843 | 450 | 7.0 | 1.100 | TO-220AB |
| MTP4N45 | 450 | 4.0 | 1.500 | TO-220AB |
| IRF831 | 450 | 4.5 | 1.500 | TO-220AB |
| IRF833 | 450 | 4.0 | 2.000 | TO-220AB |
| IRF821 | 450 | 2.5 | 3.000 | TO-220AB |
| IRF823 | 450 | 2.0 | 4.000 | TO-220AB |
| MTP2N45 | 450 | 3.0 | 4.000 | TO-220AB |
| IRFP350CF | 400 | 18.0 | 0.340 | TO-3P |
| IRFP350 | 400 | 16.2 | 0.300 | TO-3P |
| IRF740CF | 400 | 11.0 | 0.440 | TO-220AB |
| IRFP340CF | 400 | 12.0 | 0.440 | TO-3P |
| IRF740 | 400 | 10.0 | 0.550 | TO-220AB |
| IRFP340 | 400 | 11.0 | 0.550 | TO-3P |
| IRF742 | 400 | 8.0 | 0.800 | TO-220AB |
| IRF730CF | 400 | 6.2 | 0.800 | TO-220AB |
| IRF730 | 400 | 5.5 | 1.000 | TO-220AB |
| MTP5N40 | 400 | 5.0 | 1.000 | TO-220AB |
| IRF720CF | 400 | 3.8 | 1.440 | TO-220AB |
| IRF732 | 400 | 4.5 | 1.500 | TO-220AB |
| IRF720 | 400 | 3.0 | 1.800 | TO-220AB |
| IRF722 | 400 | 2.5 | 2.500 | TO-220AB |
| MTP3N40 | 400 | 3.0 | 3.300 | TO-220AB |
| IRF710 | 400 | 1.5 | 3.600 | TO-220AB |
| IRF712 | 400 | 1.3 | 5.000 | TO-220AB |
| MTP2N40 | 400 | 2.0 | 5.000 | TO-220AB |

# Power Electronic Components (Continued)

## Plastic Encapsulated Packages (TO-220AB/TO-3P) (Continued)

| Device | $V_{DSS}$ (V) | $I_{DR}$ (A) | $r_{DS(on)}$ (Ω) | Package Types |
|---|---|---|---|---|
| IRFP351CF | 350 | 18.0 | 0.240 | TO-3P |
| IRFP351 | 350 | 16.2 | 0.300 | TO-3P |
| IRFP341CF | 350 | 12.0 | 0.440 | TO-3P |
| IRF741 | 350 | 10.0 | 0.550 | TO-220AB |
| IRFP341 | 350 | 11.0 | 0.550 | TO-3P |
| IRF743 | 350 | 8.0 | 0.800 | TO-220AB |
| IRF731 | 350 | 5.5 | 1.000 | TO-220AB |
| MTP5N35 | 350 | 5.0 | 1.000 | TO-220AB |
| IRF733 | 350 | 4.5 | 1.500 | TO-220AB |
| IRF721 | 350 | 3.0 | 1.800 | TO-220AB |
| IRF723 | 350 | 2.5 | 2.500 | TO-220AB |
| MTP3N35 | 350 | 3.0 | 3.300 | TO-220AB |
| IRF711 | 350 | 1.5 | 3.600 | TO-220AB |
| IRF713 | 350 | 1.3 | 5.000 | TO-220AB |
| MTP2N35 | 350 | 2.0 | 5.000 | TO-220AB |
| IRFP250CF | 200 | 32.9 | 0.068 | TO-3P |
| IRFP250 | 200 | 32.5 | 0.085 | TO-3P |
| IRF640CF | 200 | 20.0 | 0.144 | TO-220AB |
| IRFP240CF | 200 | 28.0 | 0.144 | TO-220AB |
| IRF640 | 200 | 18.0 | 0.180 | TO-220AB |
| IRFP240 | 200 | 19.8 | 0.180 | TO-3P |
| IRF642 | 200 | 16.0 | 0.220 | TO-220AB |
| IRF630CF | 200 | 10.0 | 0.320 | TO-220AB |
| MTP12N20 | 200 | 10.0 | 0.320 | TO-220AB |
| IRF630 | 200 | 9.0 | 0.400 | TO-220AB |
| IRF632 | 200 | 8.0 | 0.600 | TO-220AB |
| IRF620CF | 200 | 5.6 | 0.640 | TO-220AB |
| MTP7N20 | 200 | 7.0 | 0.700 | TO-220AB |
| IRF620 | 200 | 5.0 | 0.800 | TO-220AB |
| IRF622 | 200 | 4.0 | 1.200 | TO-220AB |
| IRF610 | 200 | 2.5 | 1.500 | TO-220AB |
| MTP2N20 | 200 | 3.3 | 1.800 | TO-220AB |
| IRF612 | 200 | 2.0 | 2.400 | TO-220AB |
| MTP12N18 | 180 | 12.0 | 0.350 | TO-220AB |
| MTP7N18 | 180 | 7.0 | 0.700 | TO-220AB |
| MTP2N18 | 180 | 3.3 | 1.800 | TO-220AB |

# Power Electronic Components (Continued)

## Plastic Encapsulated Packages (TO-220AB/TO-3P) (Continued)

| Device | $V_{DSS}$ (V) | $I_{DR}$ (A) | $r_{DS\,(on)}$ (Ω) | Package Types |
|---|---|---|---|---|
| IRFP251CF | 150 | 38.9 | 0.068 | TO-3P |
| IRFP251 | 150 | 32.5 | 0.085 | TO-3P |
| IRFP241CF | 150 | 28.0 | 0.144 | TO-3P |
| IRF641 | 150 | 18.0 | 0.180 | TO-220AB |
| IRFP241 | 150 | 19.8 | 0.180 | TO-3P |
| IRF643 | 150 | 16.0 | 0.220 | TO-220AB |
| IRF631 | 150 | 9.0 | 0.400 | TO-220AB |
| IRF633 | 150 | 8.0 | 0.600 | TO-220AB |
| IRF621 | 150 | 5.0 | 0.800 | TO-220AB |
| IRF623 | 150 | 4.0 | 1.200 | TO-220AB |
| IRF611 | 150 | 2.5 | 1.500 | TO-220AB |
| IRF613 | 150 | 2.0 | 2.400 | TO-220AB |
| IRFP150CF | 100 | 47.5 | 0.044 | TO-3P |
| IRFP150 | 100 | 43.0 | 0.055 | TO-3P |
| IRF540CF | 100 | 30.0 | 0.068 | TO-220AB |
| IRFP140CF | 100 | 33.0 | 0.068 | TO-3P |
| IRF540 | 100 | 27.0 | 0.085 | TO-220AB |
| IRFP140 | 100 | 29.5 | 0.085 | TO-3P |
| IRF542 | 100 | 24.0 | 0.110 | TO-220AB |
| IRF530CF | 100 | 16.0 | 0.144 | TO-220AB |
| MTP20N10 | 100 | 20.0 | 0.150 | TO-220AB |
| IRF530 | 100 | 14.0 | 0.180 | TO-220AB |
| IRF520CF | 100 | 9.1 | 0.240 | TO-220AB |
| IRF532 | 100 | 12.0 | 0.250 | TO-220AB |
| IRF520 | 100 | 8.0 | 0.300 | TO-220AB |
| MTP10N10 | 100 | 10.0 | 0.330 | TO-220AB |
| IRF522 | 100 | 7.0 | 0.400 | TO-220AB |
| IRF510 | 100 | 12.0 | 0.600 | TO-220AB |
| IRF512 | 100 | 3.5 | 0.800 | TO-220AB |
| MTP4N10 | 100 | 5.0 | 0.800 | TO-220AB |
| MTP20N08 | 80 | 20.0 | 0.150 | TO-220AB |
| MTP10N08 | 80 | 10.0 | 0.330 | TO-220AB |
| MTP4N08 | 80 | 5.0 | 0.800 | TO-220AB |

# Power Electronic Components (Continued)

## Plastic Encapsulated Packages (TO-220AB/TO-3P) (Continued)

| Device | $V_{DSS}$ (V) | $I_{DR}$ (A) | $r_{DS(on)}$ (Ω) | Package Types |
|---|---|---|---|---|
| IRFP151CF | 60 | 47.5 | 0.044 | TO-3P |
| IRFP151 | 60 | 43.0 | 0.055 | TO-3P |
| IRFP141CF | 60 | 33.0 | 0.068 | TO-3P |
| IRF541 | 60 | 27.0 | 0.085 | TO-220AB |
| IRFP141 | 60 | 29.5 | 0.085 | TO-3P |
| FMP20N06 | 60 | 20.0 | 0.085 | TO-220AB |
| FMP18N06 | 60 | 18.0 | 0.100 | TO-220AB |
| IRF543 | 60 | 24.0 | 0.110 | TO-220AB |
| IRF531 | 60 | 14.0 | 0.180 | TO-220AB |
| IRF533 | 60 | 12.0 | 0.250 | TO-220AB |
| IRF521 | 60 | 8.0 | 0.300 | TO-220AB |
| IRF523 | 60 | 7.0 | 0.400 | TO-220AB |
| IRF511 | 60 | 4.0 | 0.600 | TO-220AB |
| IRF513 | 60 | 3.5 | 0.800 | TO-220AB |
| FMP20N05 | 50 | 20.0 | 0.085 | TO-220AB |
| FMP18N05 | 50 | 18.0 | 0.100 | TO-220AB |

## COOLFETs

| Device | $V_{DSS}$ (V) | $I_D$ (Max.) (A) | $r_{DS(on)}$ (Max.) (Ω) | Power Dissipation (W) | Package Types |
|---|---|---|---|---|---|
| IRF820CF | 500 | 2.8 | 2.400 | 40 | TO-220AB |
| IRF830CF | 500 | 5.0 | 1.200 | 75 | TO-220AB |
| IRF840CF | 500 | 8.9 | 0.680 | 125 | TO-220AB |
| IRF450CF | 500 | 14.5 | 0.320 | 150 | TO-204AE |
| IRF720CF | 400 | 3.4 | 1.440 | 40 | TO-220AB |
| IRF730CF | 400 | 6.2 | 0.800 | 75 | TO-220AB |
| IRF740CF | 400 | 11.0 | 0.440 | 125 | TO-220AB |
| IRF350CF | 400 | 16.8 | 0.240 | 150 | TO-204AE |
| IRF620CF | 200 | 5.6 | 0.640 | 40 | TO-220AB |
| IRF630CF | 200 | 10.0 | 0.320 | 75 | TO-220AB |
| IRF640CF | 200 | 20.0 | 0.144 | 125 | TO-220AB |
| IRF250CF | 200 | 33.0 | 0.068 | 150 | TO-204AE |
| IRF520CF | 100 | 9.1 | 0.240 | 40 | TO-220AB |
| IRF530CF | 100 | 16.0 | 0.144 | 75 | TO-220AB |
| IRF540CF | 100 | 30.0 | 0.068 | 125 | TO-220AB |
| IRF150CF | 100 | 44.0 | 0.044 | 150 | TO-204AE |

# Power Electronic Components (Continued)

## Ultrafast Reverse Recovery Rectifiers (Package TO-3P/TO-220AC)

| Device | $V_{RSM}$ (V) | $I_F$ (Avg) (A) | $t_{rr}$ (ns) | $V_F$ (V) | Package Types |
|---|---|---|---|---|---|
| FRP805 | 50 | 8 | 50 | 0.95 | TO-220AC |
| FRP810 | 100 | 8 | 50 | 0.95 | TO-220AC |
| FRP815 | 150 | 8 | 50 | 0.95 | TO-220AC |
| FRP820 | 100 | 8 | 50 | 0.95 | TO-220AC |
| FRP840 | 400 | 8 | 75 | 1.50 | TO-220AC |
| FRP850 | 500 | 8 | 75 | 1.50 | TO-220AC |
| FRP860 | 600 | 8 | 75 | 1.50 | TO-220AC |
| FRP1005 | 50 | 10 | 50 | 0.95 | TO-220AC |
| FRP1010 | 100 | 10 | 50 | 0.95 | TO-220AC |
| FRP1015 | 150 | 10 | 50 | 0.95 | TO-220AC |
| FRP1020 | 200 | 10 | 50 | 0.95 | TO-220AC |
| FRP1605 | 50 | 16 | 50 | 0.95 | TO-220AC |
| FRP1610 | 100 | 16 | 50 | 0.95 | TO-220AC |
| FRP1615 | 150 | 16 | 50 | 0.95 | TO-220AC |
| FRP1620 | 200 | 16 | 50 | 0.95 | TO-220AC |
| FRK1605 | 50 | 16 | 50 | 0.95 | TO-3P |
| FRK1610 | 100 | 16 | 50 | 0.95 | TO-3P |
| FRK1615 | 150 | 16 | 50 | 0.95 | TO-3P |
| FRK1620 | 200 | 16 | 50 | 0.95 | TO-3P |

## Dual Rectifiers, Common Cathode (Package TO-3P/TO-220AB)

| Device | $V_{RSM}$ (V) | $I_F$ (Avg) (A) | $t_{rr}$ (ns) | $V_F$ (V) | Package Types |
|---|---|---|---|---|---|
| FRP1605CC | 50 | 16 | 50 | 0.95 | TO-220AB |
| FRP1610CC | 100 | 16 | 50 | 0.95 | TO-220AB |
| FRP1615CC | 150 | 16 | 50 | 0.95 | TO-220AB |
| FRP1620CC | 200 | 16 | 50 | 0.95 | TO-220AB |
| FRP1640CC | 400 | 8 | 75 | 1.50 | TO-220AB |
| FRP1650CC | 500 | 8 | 75 | 1.50 | TO-220AB |
| FRP1660CC | 600 | 8 | 75 | 1.50 | TO-220AB |
| FRP2005CC | 50 | 20 | 50 | 0.95 | TO-220AB |
| FRP2010CC | 100 | 20 | 50 | 0.95 | TO-220AB |
| FRP2015CC | 150 | 20 | 50 | 0.95 | TO-220AB |
| FRP2020CC | 200 | 20 | 50 | 0.95 | TO-220AB |
| FRK3205CC | 50 | 32 | 50 | 0.95 | TO-3P |
| FRK3210CC | 100 | 32 | 50 | 0.95 | TO-3P |
| FRK3215CC | 150 | 32 | 50 | 0.95 | TO-3P |
| FRK3220CC | 200 | 32 | 50 | 0.95 | TO-3P |

# Programmable Logic

For additional Programmable Logic products, see page 155.

# Programmable Logic

Fairchild's programmable logic family is focused on the high-performance FASTPLAs. Combining unique architectural features, high speed, and low power, these products enable designers to create for themselves any functions they wish to add to the FAST family. In addition, the product line includes the 93Z459 FPLA, which is fabricated using Fairchild's proprietary Isoplanar-Z™ process, providing all of the density, speed, and reliability of vertical fuse programming.

# FASTPLAs (16XX)

## FAST Programmable Logic Arrays (FASTPLAs)

| Device | Array Inputs | Logic | OE | Outputs | Speed | Pins | Package Codes |
|---|---|---|---|---|---|---|---|
| 16L8D | 10 Dedicated | 8 7-Wide AND/OR | 8 Individually Programmable | 6 Bidirectional<br>2 Dedicated | 10 ns | 20 | PC, DC, QC |
| 16R8D | 8 Dedicated<br>1 Clock | 8 8-Wide AND/OR | 8 Dedicated | 8 Registered (w/Feedback) | 10 ns | 20 | PC, DC, QC |
| 16R6D | 8 Dedicated<br>1 Clock | 2 7-Wide AND/OR<br>6 8-Wide AND/OR | 2 Individually Programmable<br>6 Dedicated | 2 Bidirectional<br>6 Registered (w/Feedback) | 10 ns | 20 | PC, DC, QC |
| 16R4D | 8 Dedicated<br>1 Clock | 4 7-Wide AND/OR<br>4 8-Wide AND/OR | 4 Individually Programmable<br>4 Dedicated | 4 Bidirectional<br>4 Registered (w/Feedback) | 10 ns | 20 | PC, DC, QC |

# Field Programmable Logic Arrays (93ZXX)

## Field Programmable Logic Arrays

| Device | Type | Speed | Pins | Package Codes |
|---|---|---|---|---|
| F93Z459A | 16 × 48 × 8, Isoplanar-Z Fuse, 3-State | 45 ns | 28 | DC, DM, FM, LM |

# Telecommunications

For additional Telecommunications products, see page 161.

# Telecommunications

Fairchild telecommunications products utilize combined analog-digital LSI designs fabricated with Fairchild's advanced double-poly CMOS process. Included are the μA212AT and μAV22 single-chip 1200 bps modems, and COMBOs™.

## μA212AT and μAV22 1200 bps Modems

Fairchild's μA212AT is the single-chip solution to Bell 212A/103-compatible modem designs. It provides such features as analog loopback, remote and local digital loopback, and self-test patterns. Handshaking for remote loopback is included on-chip. Applications utilizing smart dialing are enhanced by call-progress tone detection (busy, dial, and ringback) and DTMF tone generation. The μA212AT's amazing 35 mW (typical) power dissipation is unequalled in the industry—three times lower than its nearest competitor! Combined with a CMOS microcontroller, the μA212AT provides extremely power-efficient portable, and battery- and line-powered modem designs.

The μAV22 1200/600 bps single-chip modem performs all signal processing required for a CCITT V.22 Alternative B-compatible modem, including selection of 550 or 1800 Hz guard tones and up to 2.3% overspeed in asynchronous operation. Pin-compatible with the μA212AT, the μAV22 also offers analog loopback, local and remote digital loopback, and "smart dialer" functions (DTMF dialing and call-progress tone detection). Its power dissipation of 40 mW (typical) is second only to that of the μA212AT.

The stunning line performance of both products is unsurpassed among all integrated 212A/V.22 products utilizing fixed equalization, and approaches that of adaptively equalized units.

The μA212AT/μAV22 combination reduces modem design to the provision of microcontroller code and a telephone line interface. Fairchild has extensive and easily modified code available for several popular microcontroller families, as well as considerable expertise in design of the line interface.

# Full Duplex Modem Chip
# μA212ATDC

## General Description

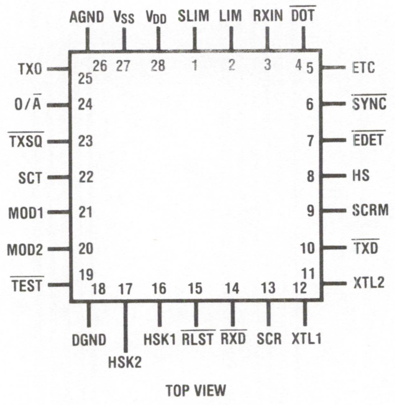
The μA212AT single-chip modem IC performs all signal processing functions required for a Bell 212A/103-compatible modem. Handshaking protocols and mode control functions are provided by a general-purpose single-chip microcontroller. The μA212AT and microcontroller, along with several components to handle the control and telephone line interfaces, provide a high-performance, cost-effective solution for an intelligent Bell 212A-compatible modem design.

The modem chip performs the modulation, demodulation, filtering, and certain control and self-test functions required for a Bell 212A-compatible modem, as well as additional functional enhancements. Switched-capacitor filters provide channel isolation, spectral shaping, and fixed compromise equalization for both high and low speed modes.

A novel switched-capacitor modulator and a digital coherent demodulator provide 1200 bps QPSK operation while a separate digital FSK modulator and demodulator handle the 0-300 bps requirement. The μA212AT includes an integral DTMF tone generator on-chip. The receive filter and energy detector may be configured for call-progress tone detection (dial tone, busy, ringback, voice), providing the front end for a smart dialer.

The μA212AT is fabricated in Fairchild's advanced double-poly silicon-gate CMOS process.

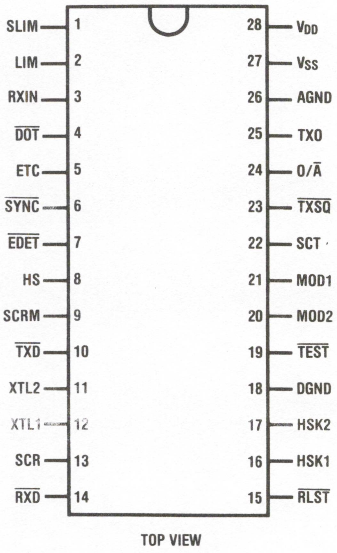
**28-Lead PLCC**


AGND
Vss
VDD
SLIM
LIM
RXIN
DOT
26 27 28 1 2 3 4
5 ETC
6 SYNC
7 EDET
8 HS
9 SCRM
10 TXD
11 XTL2
TXO 25
O/A 24
TXSQ 23
SCT 22
MOD1 21
MOD2 20
TEST 19
18 17 16 15 14 13 12
DGND
HSK2
HSK1
RLST
RXD
SCR
XTL1
TOP VIEW

## Features

- Functions as a 212A- and 103-compatible modem
- Performs all single processing functions
- Interfaces to single-chip microcontroller, which handles handshaking protocols and mode control functions
- DTMF tone generation
- Pin- and firmware-compatible with the μA212A (without integral DTMF) for easy upgrade
- Call-progress tone detection for smart dialer applications
- On-chip oscillator uses standard 3.6864 MHz crystal
- Few external components required
- Industrial temperature range option (– 40°C to + 85°C)
- Operates from + 5V and – 5V supplies
- Low operating power: 35mW typical
- 28-lead ceramic DIP, 28-lead plastic DIP, and 28-lead plastic leaded chip carrier (PLCC)
- μA212AT designer's kit is available

**28-Lead DIP**


SLIM 1
LIM 2
RXIN 3
DOT 4
ETC 5
SYNC 6
EDET 7
HS 8
SCRM 9
TXD 10
XTL2 11
XTL1 12
SCR 13
RXD 14
28 VDD
27 Vss
26 AGND
25 TXO
24 O/A
23 TXSQ
22 SCT
21 MOD1
20 MOD2
19 TEST
18 DGND
17 HSK2
16 HSK1
15 RLST
TOP VIEW

# Full Duplex Modem Chip
# μAV22

## General Description

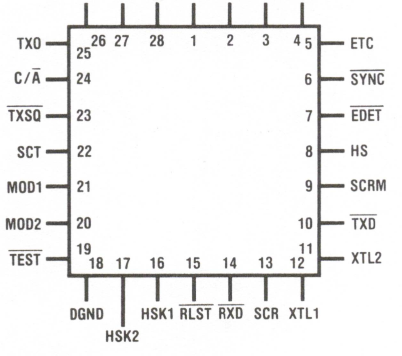
The μAV22 1200/600 bps single-chip modem IC performs all signal processing required for a CCITT V.22 Alternative B-compatible modem, while typically dissipating only 40 mW. Handshaking protocols and dialing mode control functions can be serviced by a general-purpose single-chip microcontroller. These two chips, along with several components to handle the control and telephone line interfaces, provide a cost-effective approach compared to either discrete or integrated chip set designs.

The modem chip performs the required V.22 modulation, demodulation, buffering, filtering, scrambling, descrambling, and control and self-test functions, as well as additional functional enhancements. A novel switched-capacitor modulator and a digital coherent demodulator provide 1200 and 600 bps QPSK operation.

Switched-capacitor filters provide channel isolation, spectral shaping, fixed compromise equalization, and guard tone rejection. Additionally, the receive filter and energy detector may be configured for call-progress tone detection (dial tone, busy, ringback, voice) in the 350 to 850 Hz band, providing the front end for a smart V.25-compatible dialer. On-chip tone generators provide DTMF dialing, 1300 Hz calling tone, 2100 Hz answer tone, and selectable 550 and 1800 Hz guard tones. The μAV22 also supports the Extended Signaling Rate Option (up to 2.3% overspeed in asynchronous mode) and provides on-chip handshaking for Remote Digital Loop (V.54/Loop 2).

The μAV22 is fabricated in Fairchild's advanced double-poly silicon-gate CMOS process.

**28-Lead PLCC**

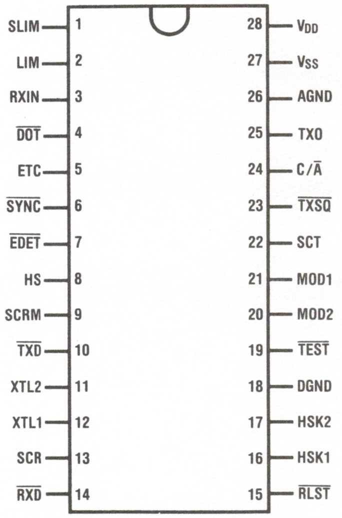

AGND
VSS
VDD
SLIM
LIM
RXIN
DOT
26 27 28 1 2 3 4
25 5
TXO
ETC
C/A
24
6
SYNC
TXSQ
23
7
EDET
SCT
22
8
HS
MOD1
21
9
SCRM
MOD2
20
10
TXD
TEST
19
11
XTL2
18 17 16 15 14 13 12
DGND
HSK2
HSK1
RLST
RXD
SCR
XTL1

TOP VIEW

## Features

- Performs all V.22 Alternative-B signal processing
- Very low power dissipation (40 mW typical)
- Excellent bit error rate (BER) performance
- Interface to a microcontroller or bus for mode and handshake control
- Selectable extended signaling rate range
- On-chip tone generators provide:
  DTMF dialing
  1300 Hz calling tone
  2100 Hz answer tone
  Selectable 550 and 1800 Hz guard tones
- Call-progress tone detection
- Supports V.54 diagnostics on-chip
  Loop 1 (local digital loop)
  Loop 2 (remote digital loop)
  Loop 3 (analog loop)
- On-chip oscillator uses 3.6864 MHz crystal
- Requires ± 5V
- Requires few external components
- Available in three 28-lead packages:
  Ceramic DIP
  Plastic DIP
  Plastic Leaded Chip Carrier (PLCC)

**28-Lead DIP**


SLIM 1
LIM 2
RXIN 3
DOT 4
ETC 5
SYNC 6
EDET 7
HS 8
SCRM 9
TXD 10
XTL2 11
XTL1 12
SCR 13
RXD 14
28 VDD
27 VSS
26 AGND
25 TXO
24 C/A
23 TXSQ
22 SCT
21 MOD1
20 MOD2
19 TEST
18 DGND
17 HSK2
16 HSK1
15 RLST

TOP VIEW

# Aerospace & Defense

For additional information on Military/Aerospace, see page 167.

# Aerospace and Defense

## MIL-STD-883 (QB) Part Numbering System

XXXX X X X X

Screening/QCI
QB = MIL-STD-883 Level B Process Flow

Temperature Range
M = −55°C to 125°C

Package Code
C = Leadless 20-Pin
D = Ceramic DIP
F = Ceramic Flatpak
G = Ceramic Gull-Wing DIP
H = TO-5 Type Metal Can
J = Ceramic Side-Brazed DIP
K = TO-3 Type Metal Can
L = Ceramic Leadless Chip Carrier (LCC)
R = Ceramic 8-Pin DIP
SD = Ceramic Slim DIP

Product Grade
(If Applicable)

Basic Device Type

## MIL-M-38510 (JAN) Part Numbering System

J® M38510/ XXX XX X X X

Lead Finish

| | |
|---|---|
| A | Hot Solder Dip |
| B | Tin Plate |
| C | Gold Plate |
| X | Any Finish |

Package Type

| | |
|---|---|
| A | 14-Lead 1/4 × 1/4 Flatpak |
| B | 14-Lead 1/4 × 1/8 Flatpak |
| C | 14-Lead 1/4 × 3/4 DIP |
| D | 14-Lead 1/4 × 3/8 Flatpak |
| E | 16-Lead 1/4 × 7/8 DIP |
| F | 16-Lead 1/4 × 3/8 Flatpak |
| G | 8-Lead Can |
| H | 10-Lead 1/4 × 1/4 Flatpak |
| I | 10-Lead Can |
| J | 24-Lead 1/2 × 1-1/4 DIP |
| K | 24-Lead 3/8 × 5/8 Flatpak |
| P | 8-Lead 1/4 × 3/8 DIP |
| R | 20-Lead 1/4 × 1-1/16 DIP |
| S | 20-Lead 1/4 × 1/2 Flatpak |
| X | 3-Lead Can |
| Y | 2-Lead TO-3 Can |
| Z | 24-Lead 1/4 × 3/8 Flatpak |
| 2 | 20-Terminal LCC 0.350 × 0.350 |

Others as Designated

Processing Level
S
B

Device Type

Detail Specification

General Procurement Specification

JAN® Designator
Cannot be marked with "J" unless qualified on Part I or II of the QPL.

For complete information on MIL-STD-883, JAN and other aerospace/defense product availability, contact your National Sales Representative.

## Digital, Linear and Memory Process Flow — MIL-STD-883 (QB)

Note: Compliant to MIL-STD-883C paragraph 1.2 only as noted on the appropriate product pages.

| Process Step | Method | Condition | Requirement |
|---|---|---|---|
| Internal Visual | 2010 | B | 100% |
| Stabilization Bake | 1008 | C | 100% |
| Temperature Cycle | 1010 | C | 100% |
| Constant Acceleration | 2001 | E (D, if applicable) | 100% |
| Fine Leak | 1014 | B | 100% (optional) |
| Gross Leak | 1014 | C | 100% (optional) |
| Interim Electricals | 5004 | Fairchild Table I | 100% |
| Burn-In | 1015 | C or D | 100% |
| **Final Electricals** | | | |
| DC + 25°C* | 5004 | Fairchild Table I | 100% |
| PDA | 5004 | 5% Max. Allowed | |
| DC + 125°C* | 5004 | Fairchild Table I | 100% |
| DC – 55°C* | 5004 | Fairchild Table I | 100% |
| AC + 25°C | 5004 | Fairchild Table I | 100% |
| **Group A** | | | **Sample Size = 116**<br>**ACC No. = 0** |
| Applicable Subgroups | 5005 | Fairchild Table I | Per Subgroup |
| Fine Leak | 1014 | B | 2% LTPD or 100% |
| Gross Leak | 1014 | C | 2% LTPD or 100% |
| External Visual | 2009 | | 100% |
| Group B, C, D | 5005 | Generic Data | Sampled |

*Includes functional testing.

## Digital, Linear and Memory Process Flow — MIL-M-38510 (JAN) Class B

| Process Step | Method | Condition | Requirement |
|---|---|---|---|
| Internal Visual | 2010 | B | 100 % |
| Stabilization Bake | 1008 | C | 100 % |
| Temperature Cycle | 1010 | C | 100 % |
| Constant Acceleration | 2001 | E (D, if applicable) | 100 % |
| Fine Leak | 1014 | B | 100 % (optional) |
| Gross Leak | 1014 | C | 100 % (optional) |
| Pre Burn-In Electricals | 5004 | Slash Sheet | 100 % |
| Burn-In | 1015 | D | 100 % |
| **Final Electricals** | | | |
| DC + 25°C* | 5004 | Slash Sheet | 100 % |
| PDA | | 5 % Maximum | |
| DC + 125°C* | 5004 | Slash Sheet | 100 % |
| DC – 55°C* | 5004 | Slash Sheet | 100 % |
| AC + 25°C | 5004 | Slash Sheet | 100 % |
| **Group A** | | | **Sample Size = 116**<br>**ACC No. = 0** |
| Applicable Subgroups | 5005 | Slash Sheet | Per Subgroup |
| Fine Leak | 1014 | B | 2 % LTPD or 100 % |
| Gross Leak | 1014 | C | 2 % LTPD or 100 % |
| External Visual | 2009 | | 100 % |
| Group B, C, D | 5005 | JAN Data | Sampled |

*Includes functional testing.

For complete information on MIL-STD-883, JAN and other aerospace/defense product availability, contact your National Sales Representative.

## Digital Process Flow—MIL-M-38510 (JAN) Class S

| Process Step | Method | Condition | Requirement |
|---|---|---|---|
| Wafer Lot Acceptance | 5007 | | All Lots |
| Non-Destructive Bond Pull | 2023 | | 100% |
| Internal Visual | 2010 | A | 100% |
| Stabilization Bake | 1008 | C | 100% |
| Temperature Cycling | 1010 | C | 100% |
| Constant Acceleration | 2001 | E | 100% |
| Serialization | | | 100% |
| Radiographic | 2012 | Two Views | 100% |
| Pre Burn-In Electricals | 5004 | Slash Sheet | 100% |
| PIND Testing | 2020 | A | 100% |
| Burn-In | 1015 | D, 240 Hrs./125°C Min. | 100% |
| **Final Electricals** | | | |
| DC + 25°C* | 5004 | Slash Sheet | 100% |
| PDA | | 3% Func. and 5% DC Max. | |
| Read & Record + 25°C | 5004 | Slash Sheet | 100% |
| DC + 125°C* | 5004 | Slash Sheet | 100% |
| DC − 55°C* | 5004 | Slash Sheet | 100% |
| AC + 25°C | 5004 | Slash Sheet | 100% |
| AC + 125°C (if required) | 5004 | Slash Sheet | 100% |
| AC − 55°C (if required) | 5004 | Slash Sheet | 100% |
| **Group A** | | | **Sample Size = 116**<br>**ACC No. = 0** |
| DC + 25°C* | 5005 | Slash Sheet | Per Subgroup |
| DC + 125°C* | 5005 | Slash Sheet | Per Subgroup |
| DC − 55°C* | 5005 | Slash Sheet | Per Subgroup |
| AC + 25°C | 5005 | Slash Sheet | Per Subgroup |
| AC + 125°C | 5005 | Slash Sheet | Per Subgroup |
| AC − 55°C | 5005 | Slash Sheet | Per Subgroup |
| Fine Leak | 1014 | B | 100% |
| Gross Leak | 1014 | C | 100% |
| External Visual | 2009 | | 100% |
| Group B & D | 5005 | JAN Data | Sampled |

*Includes functional testing.

# Device/JAN Cross Reference

## Digital

| Device | JAN/ Sheet | Device Type |
|---|---|---|
| **FAST® (54FXX)** | | |
| 54F00 | 330 | 01 |
| 54F02 | 333 | 01 |
| 54F04 | 330 | 02 |
| 54F08 | 340 | 01 |
| 54F10 | 330 | 03 |
| 54F11 | 340 | 02 |
| 54F20 | 330 | 04 |
| 54F32 | 335 | 01 |
| 54F64 | 334 | 01 |
| 54F74 | 341 | 01 |
| 54F86 | 345 | 01 |
| 54F109 | 341 | 02 |
| 54F138 | 337 | 01 |
| 54F139 | 337 | 02 |
| 54F151 | 339 | 01 |
| 54F153 | 339 | 02 |
| 54F157 | 339 | 03 |
| 54F158 | 339 | 04 |
| 54F160A | 344 | 01 |
| 54F161A | 343 | 01 |
| 54F162A | 344 | 02 |
| 54F163A | 343 | 02 |
| 54F174 | 341 | 07 |
| 54F175 | 341 | 04 |
| 54F181 | 338 | 01 |
| 54F192 | 344 | 04 |
| 54F193 | 343 | 04 |
| 54F240 | 332 | 01 |
| 54F241 | 332 | 02 |
| 54F244 | 332 | 03 |
| 54F251 | 339 | 05 |
| 54F253 | 339 | 08 |
| 54F257 | 339 | 06 |
| 54F258 | 339 | 07 |
| 54F280 | 349 | 01 |
| 54F283 | 342 | 01 |
| 54F352 | 339 | 09 |
| 54F353 | 339 | 10 |
| 54F373 | 346 | 01 |
| 54F374 | 341 | 05 |
| 54F398 | 350 | 01 |
| 54F399 | 350 | 02 |
| 54F521 | 347 | 01 |
| 54F533 | 346 | 02 |
| 54F563 | 346 | 03 |
| 54F573 | 346 | 04 |

| Device | JAN/ Sheet | Device Type |
|---|---|---|
| **Low Power Schottky (54LSXX)** | | |
| 54LS00 | 300 | 01 |
| 54LS02 | 303 | 01 |
| 54LS03 | 300 | 02 |
| 54LS04 | 300 | 03 |
| 54LS05 | 330 | 04 |
| 54LS08 | 310 | 04 |
| 54LS10 | 300 | 05 |
| 54LS11 | 310 | 01 |
| 54LS20 | 300 | 07 |
| 54LS21 | 310 | 03 |
| 54LS22 | 300 | 08 |
| 54LS27 | 303 | 02 |
| 54LS30 | 300 | 09 |
| 54LS32 | 305 | 01 |
| 54LS42 | 307 | 03 |
| 54LS51 | 304 | 01 |
| 54LS54 | 304 | 02 |
| 54LS74 | 301 | 02 |
| 54LS83A | 312 | 01 |
| 54LS85 | 311 | 01 |
| 54LS95 | 306 | 03 |
| 54LS109 | 301 | 09 |
| 54LS112 | 301 | 03 |
| 54LS113 | 301 | 04 |
| 54LS114 | 301 | 05 |
| 54LS138 | 307 | 01 |
| 54LS139 | 307 | 02 |
| 54LS151 | 309 | 01 |
| 54LS153 | 309 | 02 |
| 54LS157 | 309 | 03 |
| 54LS158 | 309 | 04 |
| 54LS174 | 301 | 06 |
| 54LS175 | 301 | 07 |
| 54LS193 | 315 | 08 |
| 54LS194A | 306 | 01 |
| 54LS240 | 324 | 01 |
| 54LS241 | 324 | 02 |
| 54LS244 | 324 | 03 |
| 54LS253 | 309 | 08 |
| 54LS257A | 309 | 06 |
| 54LS258A | 309 | 07 |
| 54LS259 | 316 | 03 |
| 54LS266 | 303 | 03 |
| 54LS273 | 325 | 01 |
| 54LS279 | 316 | 02 |
| 54LS283 | 312 | 02 |
| 54LS365A | 322 | 01 |
| 54LS366A | 322 | 02 |
| 54LS367A | 322 | 03 |
| 54LS368A | 322 | 04 |

| Device | JAN/ Sheet | Device Type |
|---|---|---|
| **Standard TTL (54XX)** | | |
| 5400 | 001 | 04 |
| 5402 | 004 | 01 |
| 5404 | 001 | 05 |
| 5408 | 016 | 01 |
| 5409 | 016 | 02 |
| 5410 | 001 | 03 |
| 5420 | 001 | 02 |
| 5430 | 001 | 01 |
| 5437 | 003 | 02 |
| 5440 | 003 | 01 |
| 5442A | 010 | 01 |
| 5474 | 002 | 05 |
| 5483A | 006 | 02 |
| 5486 | 007 | 01 |
| 54121 | 012 | 01 |
| 54122 | 012 | 02 |
| 54123 | 012 | 03 |
| 54151A | 014 | 06 |
| 54153 | 014 | 03 |
| 54157 | 014 | 05 |
| 54174 | 017 | 01 |
| 54175 | 017 | 02 |
| **TTL 9300** | | |
| 9309 | 014 | 04 |
| 9322 | 014 | 05 |
| **TTL 9600** | | |
| 9601 | 012 | 04 |
| 9602 | 012 | 05 |
| **DTL (930)** | | |
| 930 | 030 | 01 |
| 936 | 030 | 03 |
| 946 | 030 | 04 |
| 962 | 030 | 05 |

For complete information on MIL-STD-883, JAN and other aerospace/defense product availability, contact your National Sales Representative.

# Device/JAN Cross Reference (Continued)

## Linear

| Device | JAN/ Sheet | Device Type |
|---|---|---|
| **Operational Amplifiers** | | |
| 101,A | 101 | 03 |
| 108, A | 101 | 04 |
| 124 | 110 | 05 |
| 148 | 110 | 01 |
| 741,A | 101 | 01 |
| 747,A | 101 | 02 |
| 771B | 119 | 04 |
| 772B | 119 | 05 |
| 774B | 119 | 06 |
| 1558 | 101 | 08 |
| 2101,A | 101 | 05 |
| 2108,A | 101 | 06 |
| 4136,A | 110 | 04 |
| **Voltage Regulators** | | |
| 109 | 107 | 01 |
| 117H | 117 | 03 |
| 117K | 117 | 04 |
| 138 | 117 | 06 |
| 150 | 117 | 05 |
| 723 | 102 | 01 |
| 7805 | 107 | 06 |
| 7812 | 107 | 07 |
| 7815 | 107 | 08 |
| 7824 | 107 | 09 |
| 78M05 | 107 | 02 |
| 78M12 | 107 | 03 |
| 78M15 | 107 | 04 |
| 78M24 | 107 | 05 |
| 78MG | 117 | 01 |
| 7905 | 115 | 05 |
| 7912 | 115 | 06 |
| 7915 | 115 | 07 |
| 79M05 | 115 | 01 |
| 79M12 | 115 | 02 |
| 79M15 | 115 | 03 |

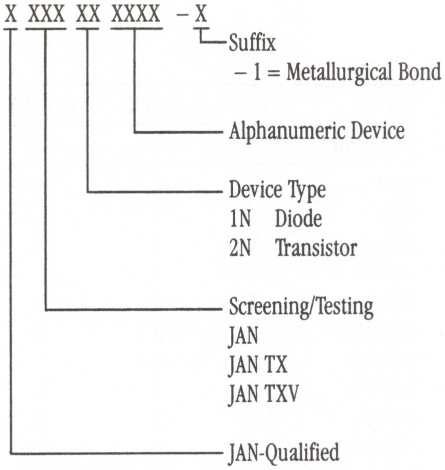
| Device | JAN/ Sheet | Device Type |
|---|---|---|
| **Interface Products** | | |
| 9614 | 104 | 03 |
| 9615 | 104 | 04 |
| 55107,A | 104 | 01 |
| **Comparators** | | |
| 110 | 106 | 02 |
| 111 | 103 | 04 |
| 139 | 112 | 01 |
| 710 | 103 | 01 |
| 711 | 103 | 02 |
| 2111 | 103 | 05 |
| **Special Functions** | | |
| 555 | 109 | 01 |
| 733 | 105 | 01 |
| 3045 | 108 | 02 |

## Memory

| Device | JAN/ Sheet | Device Type |
|---|---|---|
| **TTL SRAMs** | | |
| 93L415 | 231 | 03 |
| 93422 | 231 | 10 |
| | 231 | 14 |
| 93L422 | 231 | 12 |
| | 231 | 15 |
| 93425 | 231 | 02 |
| | 231 | 06 |
| | 231 | 08 |
| 93L425 | 231 | 04 |
| | 231 | 13 |
| **TTL PROMs** | | |
| 93Z511 | 210 | 02 |
| | 210 | 04 |

For complete information on MIL-STD-883, JAN and other aerospace/defense product availability, contact your National Sales Representative.

## MIL-S-19500 (JAN) Part Numbering System


X XXX XX XXXX -X
Suffix
- 1 = Metallurgical Bond
Alphanumeric Device
Device Type
1N Diode
2N Transistor
Screening/Testing
JAN
JAN TX
JAN TXV
JAN-Qualified

## Process Flow MIL-S-19500G (JAN) Semiconductor Devices

| Process Step | Method | Condition | Requirement |
|---|---|---|---|
| High Temperature Storage | 1032 | 24 Hours Min. | 100 % |
| Temperature Cycle | 1051 | Slash Sheet | 100 % |
| Constant Acceleration | 2006 | Slash Sheet | 100 % |
| High Temperature Gate Bias | 1042 | B | 100 % |
| Pre-Burn-In Electrical Tests | | Slash Sheet | 100 % |
| High Temperature Reverse Bias | 1042 | A | 100 % |
| Final Electrical Test | | | 100 % |
| Solder Lead Finish | | | 100 % |
| Mark | | | 100 % |
| Fine Leak | 1071 | $5 \times 10^{(-7)}$ | 100 % |
| Gross Leak | 1071 | | 100 % |
| Group A | | Slash Sheet | |

Referenced Test Methods from MIL-STD-750C.

# Device/JAN Cross Reference (Continued)

## Discrete (MIL-S-19500)

| Device | JAN | JANTX | JANTXV |
|---|---|---|---|
| **Monolithic Diode Arrays** | | | |
| 1N5768 | X | X | X |
| 1N5770 | X | X | X |
| 1N5772 | X | X | X |
| 1N5774 | X | X | X |
| 1N6100 | X | X | X |
| 1N6101 | X | X | X |
| **Small Signal Diodes** | | | |
| 1N457 | X | | |
| 1N458 | X | | |
| 1N459 | X | | |
| 1N483B | X | X | |
| 1N485B | X | X | |
| 1N486B | X | X | |
| 1N914 | X | X | |
| 1N3064 | X | X | |
| 1N3595 | X | X | X |
| 1N3600 | X | X | X |
| 1N4148-1 | X | X | X |
| 1N4150-1 | X | X | X |
| 1N4376 | X | X | X |
| 1N4454-1 | X | X | X |

| Device | JAN | JANTX | JANTXV |
|---|---|---|---|
| **Transistors** | | | |
| 2N718A | X | X | X |
| 2N930 | X | X | |
| 2N1613 | X | X | X |
| 2N2060 | X | X | |
| 2N2218A | X | X | X |
| 2N2221A | X | X | X |
| 2N2222A | X | X | X |
| 2N2369A | X | X | X |
| 2N2484 | X | X | X |
| 2N2904A | X | X | X |
| 2N2905A | X | X | X |
| 2N2906A | X | X | X |
| 2N2907A | X | X | X |
| 2N2920 | X | X | X |
| 2N3019 | X | X | X |
| 2N3700 | X | X | X |

## Power (MIL-S-19500)

| Device | JANTX | JANTXV |
|---|---|---|
| **Power MOSFETs** | | |
| 2N6756 | X | X |
| 2N6758 | X | X |
| 2N6760 | X | X |
| 2N6762 | X | X |
| 2N6764 | X | X |
| 2N6766 | X | X |
| 2N6768 | X | X |
| 2N6770 | X | X |

For complete information on MIL-STD-883, JAN and other aerospace/defense product availability, contact your National Sales Representative.

## Process Flow CMOS Hi-Rel Production Processing MIL-STD-883, Gate Array

| Process Step | Method | Condition | Requirement |
|---|---|---|---|
| Internal Visual | 2010 | B | 100 % |
| Stabilization Bake | 1008 | C | 100 % |
| Temperature Cycle | 1010 | C | 100 % |
| Constant Acceleration | 2001 | D, E (Note 1), Y1 Orientation | 100 % |
| Initial Electricals | Per Applicable Spec. | 25°C | 100 % |
| Burn-In | 1015 | A or C, 160 Hr. @ + 125°C | 100 % |
| Post Burn-In | Per Applicable Spec. | 25°C, PDA 5 % | 100 % |
| **Final Electricals** | | | |
| DC Static | Per Applicable Spec. | | |
| + 25°C Ambient | | | 100 % |
| − 55°C Ambient | | | 100 % |
| + 125°C Ambient | | | 100 % |
| DC Functional | Per Applicable Spec. | | |
| − 55°C Ambient | | | 100 % |
| + 25°C Ambient | | | 100 % |
| + 125°C Ambient | | | 100 % |
| AC (Note 2) | | | |
| + 25°C Ambient | 1014 | | 100 % |
| Seal | | | |
| Fine Leak | | B | 100 % |
| Gross Leak | | C | 100 % |
| External Visual | 2009 | | 100 % |
| **Group B** | | | **Quantity** |
| Subgroup 1 | | | 2 |
| Physical Dimensions | 2016 | | |
| Subgroup 2 | | | 4 |
| Solvent Resistance | 2015 | | |
| Subgroup 3 (Note 3) | | | 10 |
| Solderability | 2003 | | |
| Subgroup 4 | | | 1 |
| Internal Visual & Mechanical | 2014 | | |
| Subgroup 5 | | | 15 |
| Bond Strength | 2011 | | |

**Note 1:** Package dependent.

**Note 2:** Based on critical paths accepted and mutually agreed upon. Normally not tested.

**Note 3:** May deviate from MIL-STD-883 Method 2003. Solder dipped leads, if possible, may permit full military compliance. Waiver required for gold leads.

## Process Flow CMOS Hi-Rel Production Processing MIL-STD-883, Gate Array (Continued)

| Process Step | Method | Condition | Quantity |
|---|---|---|---|
| **Group C** | | | |
| Subgroup 1 | | | 5 |
| A) Steady State Life | 1005 | A or C, 1000 Hr.<br>@ + 25°C | |
| B) Endpoint Electrical | Per Applicable Spec. | | |
| Subgroup 2 | | | 15 |
| A) Temperature Cycle | 1010 | C | |
| B) Constant Acceleration | 2001 | D or E (Note 1) | |
| C) Seal | 1014 | | |
| Fine Leak | | B | |
| Gross Leak | | C | |
| D) Visual | 1010 or 1011 | | |
| E) Endpoint Electrical | Per Applicable Spec. | | |
| **Group D** | | | |
| Subgroup 1 | | | 15 |
| A) Physical Dimensions | 2016 | | |
| Subgroup 2 | | | 15 (0) |
| A) Lead Integrity (Note 2) | 2004 | | |
| B) Seal | 1014 | | |
| Fine Leak | | B | |
| Gross Leak | | C | |
| Subgroup 3 | | | 15 |
| A) Thermal Shock | 1011 | B, 15 Cycles | |
| B) Temperature Cycle | 1010 | C, 100 Cycles | |
| C) Moisture Resistance | 1004 | | |
| D) Seal | 1014 | | |
| Fine Leak | | B | |
| Gross Leak | | C | |
| E) Visual | 1004 and 1011 | | |
| F) Endpoint Electrical | Per Applicable Spec. | | |

Note 1: Package dependent; may deviate from MIL-STD-883C for extremely large VLSI packages.
Note 2: Package dependent.

## Process Flow CMOS Hi-Rel Production Processing MIL-STD-883, Gate Array (Continued)

| Process Step | Method | Condition | Quantity |
|---|---|---|---|
| **Group D** (Continued) | | | |
| Subgroup 4 | | | 15 |
| A) Mechanical Shock | 2002 | B | |
| B) Vibration, Variable Frequency | 2007 | A | |
| C) Constant Acceleration | 2001 | D or E (Note 1) | |
| D) Seal | 1014 | | |
| Fine Leak | | B | |
| Gross Leak | | C | |
| E) Visual | 1001 or 1011 | | |
| F) Endpoint Electrical | Per Applicable Spec. | | |
| Subgroup 5 | | | 15 |
| A) Salt Atmosphere | 1009 | A | |
| Gold Finish (Note 2) | | | |
| B) Seal | 1014 | | |
| Fine Leak | | B | |
| Gross Leak | | C | |
| C) Visual | 1009 | | |
| Subgroup 6 | | | 3 (0), 5 (1) |
| A) Internal Water Vapor Content, 100° | 1018 | 5000 ppm max. | |
| Subgroup 7 | | | 15 |
| A) Lead Finish Adhesion | 2025 | | |
| Subgroup 8 | | | 5 |
| A) Lid Torque (Note 3) | 2024 | | |

Note 1: Package dependent.
Note 2: Waiver required for gold lids and/or leads. Fairchild can negotiate on a case-by-case basis depending on the package.
Note 3: Lid torque test shall apply only to packages which use a glass frit seal to lead frame, lead or body package.

## Process Flow ECL Hi-Rel Production Processing MIL-STD-883, Gate Array

(Not Compliant with MIL-STD-883C)

| Process Step | Method | Condition | Requirement |
|---|---|---|---|
| Internal Visual | 2010.7 | B | 100% |
| Stabilization Bake | 1008.2 | C, 24 Hr. | 100% |
| Temperature Cycle | 1010 | C | 100% |
| Constant Acceleration | 2001, Y1 Orientation | TBD (Note 1) | 100% |
| Seal, Fine and Gross | 1014 | | 100% |
| Initial Electricals | Per Applicable Spec. | + 25°C | 100% |
| Burn-In (Note 2) | 1015 | C, 160 Hr.@ + 125°C | 100% |
| Post Burn-In | Per Applicable Spec. | + 25°C, PDA 5% | 100% |
| **Final Electricals** | | | |
| DC Static | Per Applicable Spec. | | |
| + 25°C Case | | | 100% |
| − 10°C Case | | | 100% |
| + 125°C Case | | | 100% |
| DC Functional | Per Applicable Spec. | | |
| + 25°C Case | | | 100% |
| − 10°C Case | | | 100% |
| + 125°C Case | | | 100% |
| AC (Note 3) | Per Applicable Spec. | | |
| + 25°C Case | | | 100% |
| External Visual | 2009 | | 100% |
| **Group B** | | | **Quantity** |
| Subgroup 1 | | | 2 |
| Physical Dimensions | 2016 | | |
| Subgroup 2 | | | 4 |
| Solvent Resistance | 2015 | | |
| Subgroup 3 | | | 15 |
| Solderability | 2003.3 | | |
| Subgroup 4 | | | 1 |
| Internal Visual & Mechanical | 2014 | | |
| Subgroup 5 | | | 15 |
| Bond Strength | 2011 | | |
| Subgroup 6 (Note 4) | | | 3 |
| Internal Water Vapor | 1018 | | |
| Subgroup 7 | | | 5 |
| Seal, Fine and Gross | 1014 | | |

Note 1: Package dependent.
Note 2: ECL product burn-in at + 125°C case. High-power devices to be negotiated.
Note 3: Must use Fairchild standard frequency domain test and one path only. Normally not tested.
Note 4: Required only if the package contains a dessicant.

## Process Flow ECL Hi-Rel Production Processing MIL-STD-883, Gate Array (Continued)

(Not Compliant with MIL-STD-883C)

| Process Step | Method | Condition | Quantity |
|---|---|---|---|
| **Group C** | | | |
| Subgroup 1 | | | |
| A) Steady State Life (Note 1) | 1005 | C, 1000 Hr. | |
| B) Endpoint Electrical | Per Applicable Spec. | | |
| Subgroup 2 | | | |
| A) Temperature Cycle | 1010 | C | |
| B) Constant Acceleration | 2001 | TBD (Note 2) | |
| C) Seal, Fine and Gross | 1014 | | |
| D) Visual | 1010 or 1011 | | |
| E) Endpoint Electrical | Per Applicable Spec. | | |
| **Group D** | | | |
| Subgroup 1 | | | 15 |
| A) Physical Dimensions | 2016 | | |
| Subgroup 2 | | | 15 |
| A) Lead Integrity (Note 3) | 2004 | | |
| B) Seal, Fine and Gross | 1014 | | |
| Subgroup 3 | | | 15 |
| A) Thermal Shock | 1011 | B, 15 Cycles | |
| B) Temperature Cycle | 1010 | C, 100 Cycles | |
| C) Moisture Resistance | 1004 | | |
| D) Seal, Fine and Gross | 1014 | | |
| E) Visual | 1004 and 1010 | | |
| F) Endpoint Electrical | Per Applicable Spec. | | |
| Subgroup 4 | | | |
| A) Mechanical Shock | 2002 | B | |
| B) Vibration, Variable Frequency | 2007 | A | |
| C) Constant Acceleration | 2001 | TBD (Note 2) | |
| D) Seal, Fine and Gross | 1014 | | |
| E) Visual | 1001 or 1011 | | |
| F) Endpoint Electrical | Per Applicable Spec. | | |

Note 1: ECL product burn-in at + 125°C case. High-power devices to be negotiated.
Note 2: Package dependent.
Note 3: Lead integrity not performed on pin grid arrays or leadless chip carrier. Therefore, Subgroup 2 not performed on these package types.

## Microcontroller Products

### Description

The Fairchild F9450 is a high performance microprocessor implementing the complete MIL-STD-1750A Instruction Set Architecture, which was developed specifically for real-time applications. The F9450 is defined by DESC Standard Military Drawing 84169.

The F9450 is available in two packaging styles, qualified to operate at military temperatures ranging from – 55°C to + 125°C.

The F9450 has been certified to be compliant with the MIL-STD-1750A Instruction Set Architecture by the Systems Engineering Avionics Facility (SEAFAC) at Wright Patterson AFB, Ohio.

### Process

F9450-15DMQB, F9450-15GMQB, F9450-20DMQB, F9450-20GMQB, F9451DMQB, F9451GMQB, F9452DMQB, and F9452GMQB are MIL-STD-883C certified products. Screening and QCI are performed in accordance with the requirements of MIL-M-38510 and MIL-STD-883.

The F9450 performance and test specifications are specified by Military Drawing 84169. This drawing requires the following electrical tests on all delivered product:

MIL-STD-883 Method 5004:

- DC Electrical
- AC Electrical
- Microprocessor Functional Test (75K test vectors)
  - All of the above tests are performed on all product, after burn-in at – 55°C, room temperature, and + 125°C
- MIL-STD-1750A VSW Functional Test (13 million test vectors) at room temperature.

Quality Conformance Inspection per MIL-STD-883 Method 5005

Group A and C:

- DC Electrical
- AC Electrical
- Microprocessor Functional Test (75K test vectors)
- MIL-STD-1750A VSW Functional Test (13 million test vectors)
  - All of these tests are performed on all product at – 55°C, room temperature, and + 125°C.
- Group C, 1000-hour life test units receive all of the above tests at all three temperatures at the completion of life test.

Group B and D:

- Standard 883 Method 5004 requirements

The following special requirements of Military Drawing 84169 are applicable to F9450 processes:

Para 3.7—Certification. Certification to MIL-STD-1750A verification software (VSW) test V2.1 + 2 shall be required and the manufacturer shall be listed on the Air Force VSW compliant computer list.

Note: V2.1 + 2 applicable to 8416901

Para 4.1—Sampling and inspection. Sampling and inspection procedures shall be in accordance with Section 4 of MIL-M-38510 to the extent specified in MIL-STD-883. In addition, a device shall be submitted once every 12 months of production to WPAFB (SEAFAC) for verification to MIL-STD-1750 VSW test V2.1 + 2 (see 3.7). The results of such testing shall be reported to DESC-ECS.

Para 4.2C—Subgroup 12 shall be added and shall consist of the MIL-STD-1750 VSW test at V2.1 + 2 deterministic portion only, at room ambient (see 3.7).

Para 4.3D—Subgroup 13 shall be added and shall consist of the MIL-STD-1750 VSW test V2.1 + 2, deterministic portion only, at – 55°C instant on and + 125°C Tc (see 3.7).

## Discrete Products—Analog Small Signal Custom Processing

Fairchild's Small Signal Product Group offers a complete line of Hi-Reliability devices produced in modern production facilities both onshore and offshore. Although emphasis is placed on designing and built-in quality and reliability, a complete reliability screening program has been established. Most products offered in this product guide are available in all of the following Hi-Rel configurations:

- Hi-Rel Wafers and Die
- Military Qualified Diodes and Transistors
- Source Controlled Devices (SCD)
- Custom "Level S" Processing

### Hi-Rel Wafers and Die

Wafer and Die are available in four standard configurations.

### Source Controlled Devices (SCD)

Many devices listed in this product guide are available with processing defined and controlled by customer documents, commonly referred to as SCD's. Using the Fairchild-developed Modular Processing table, along with standard test methods and conditions, complete custom processing can be designed. Fairchild will conform to the requirements of furnished documents, however, reference to modules within the Modular Processing sequence in the SCD as equal to or exceeding the requirements specified will expedite quote response and product delivery.

### Custom "Level B" Processing

Top of the line built and processed devices, requiring baseline documentation, wafer lot acceptance and traceability, clean room assembly and Level S process controls and screening are available. Consult the factory for details.

## Standard Test Methods & Conditions

| Test | MIL-STD-750 Method | Test Condition | Comments |
|---|---|---|---|
| Internal Visual | 2072, 2073, 2074 | | |
| High Temp Storage | 1032 | | 200°C, 48 hrs. |
| Temp Cycle | 1061 | C | $-65°C$ to $+200°C$, 20 cyc, 15 min. at extremes |
| Constant Acceleration | 2006 | | 30 Kg. Y1, one minute does not apply.<br>(Not applicable to DO-35 pkg.) |
| Fine Leak | 1071 | G | $5 \times 10^{-8}$ atmos cc/sec.<br>(Not applicable to DO-35 pkg.) |
| Gross Leak | 1071 | C | Test condition E for glass diodes |
| HTRB Burn-In | 1038 and 1039 | | 150°C, 48 hrs, 80% $V_{CB}$ (transistor), 80% $V_R$ (Diode) min. (use 72 hrs, if not followed by Power Burn-In) |
| Power Burn-In | 1038 and 1039 | B | Transistors—160 hrs., Diodes—96 hrs. |
| X-Ray | 2076 | | 2 views |
| External Visual | 2071 | | |
| Group A | | | MIL-STD-19500 Table III, JAN TXV |
| Group B | | | MIL-STD-19500 Table IVb |
| Group C | | | MIL-STD-19500 Table V |
| Solderability | 2026 | | LTPD = 15, Electrical rejects may be used. |
| Resistance to Solvents | 1022 | | LTPD = 15, Electrical rejects may be used. |

For complete information on MIL-STD-883, JAN and other aerospace/defense product availability, contact your National Sales Representative.

# Packaging and Order Information

For additional Packaging information, see page 181.

# Packaging and Order Information

Ever since it developed and introduced the classic through-hole plastic dual-in-line package in the early 1960s, Fairchild has been on the forefront of package technology. Today, Fairchild's products are available in the full range of industry standard through-hole packages. Fairchild devices are also available in a variety of surface-mount packages:

## Package Equivalents

| Through-Hole | Surface-Mount |
|---|---|
| Plastic DIP | Small Outline IC |
| Ceramic DIP | Ceramic Flatpak |
| Plug-In PGA | PLCC/LCC |
| Plastic and Metal Can Transistors | SOT |
| Glass Diodes | Leadless SOT (MELF) |

## Through-Hole Packaging

The most widely used through-hole packages are TOs and 14- and 16-lead plastic and ceramic dual-in-lines. TO cans cover the discrete, power, and military markets. Low power plastic DIPs, in 8 to 40 leads, represent the bulk of the commericial board market, through limited multi-layer technologies. The low power ceramic DIP models are used in military, memory, and small logic applications.

Fairchild has developed one of the highest power-dissipating through-hole packages currently available, in a 64-lead composite ceramic, which can be used as a surface-mount device in some applications.

*For more packaging and order information, please contact your local National Sales Office.

## Surface-Mount Packaging

The demand for thin, miniature packages, adaptable to high-density die size and surface conditions, has produced wide-body SOICs in 8- to 24-lead sizes. The thrust in surface-mount technology encompasses all product lines and will experience substantial growth over the next two years.

While requiring adequate board technology for effective routing, the advantages of greater lead count (from 20 to 88 pins, with 130 pins in development) make the PLCC expecially popular in high-density uses.

The ease of mounting J-lead or gull-wing packages also satisfies tight board space and routing problems.

Historically, high-reliability military applications have preferred flatpacks, which offer a wide variety of configurations and lead counts—ranging from 20 to hundreds of pins. While flatpacks are considered surface-mount packages, special commercial applications use them as through-hole packaging.

The devices listed in this guide show only the basic device numbers. This basic number forms part of a simplified order code.

XXXXX X X X X XX

Special Variations
QR = Commercial-grade device with burn-in
QB = Military-grade device with environmental and burn-in processing
T = Devices shipped in 7″ reels
X = Devices shipped in 14″ reels
TR = Commercial-grade devices with burn-in, shipped in 7″ reels
XR = Commercial-grade devices with burn-in, shipped in 14″ reels

Temperature Range
C (Commercial) = 0°C to + 70°C/+ 75°C/+ 125°C
V (Industrial) = − 25°C to + 85°C
A (Automotive) = − 40°C to + 85°C
M (Military) = − 55°C to + 125°C

Package Code
P = Plastic DIP
PC = Plastic DIP
PDIP = Plastic Dual In-Line
SP = Slim Plastic DIP
D = Ceramic DIP
DC = Ceramic DIP
CDIP = Ceramic DIP
G = Ceramic Gull-Wing DIP
SD = Slim Ceramic DIP
LDCC = Leaded Chip Carrier
PLCC = Plastic Leaded (J-Bend) Chip Carrier
CLCC = Ceramic Leaded (J-Bend) Chip Carrier
S = Small Outline IC (SOIC), 150 mils
F = Flatpack
FPK = Flatpack
LCC = Leadless Chip Carrier
L = Ceramic Leadless Chip Carrier (LCC)
L1 = Ceramic Leadless Chip Carrier (LCC)
Q = Plastic Chip Carrier (PCC)
CPGA = Ceramic Pin Grid Array

Speed Grade (If Used)

Electrical Class (If Used)

Device Type

# Surface-Mount Device Index

## Standard Logic—FACT

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| 54AC/74AC00 | Quad 2-Input Gate | X | X | X | | |
| 54ACT/74ACT00 | Quad 2-Input Gate | X | X | X | | |
| 54AC/74AC02 | Quad 2-Input NOR Gate | X | X | X | | |
| 54AC/74AC04 | Hex Inverter Gate | X | X | X | | |
| 54AC/74AC08 | Quad 2-Input Gate | X | X | X | | |
| 54AC/74AC10 | Triple 3-Input Gate | X | X | X | | |
| 54AC/74AC11 | Triple 3-Input Gate | X | X | X | | |
| 54AC/74AC14 | Hex Schmitt Trigger Gate | X | X | X | | |
| 54AC/74AC20 | Dual 4-Input Gate | X | X | X | | |
| 54AC/74AC32 | Quad 2-Input OR Gate | X | X | X | | |
| 74AC74 | Dual D Flip-Flop | X | | | | |
| 74ACT74 | Dual D Flip-Flop | X | | | | |
| 74AC109 | Dual J-K Flip-Flop | X | | | | |
| 74ACT109 | Dual J-K Flip-Flop | X | | | | |
| 54AC/74AC138 | 1-of-8 Decoder/Demultiplexer | X | X | X | | |
| 54ACT/74ACT138 | 1-of-8 Decoder/Demultiplexer | X | X | X | | |
| 54AC/74AC139 | Dual 1-of-4 Decoder/Demultiplexer | X | X | X | | |
| 54ACT/74ACT139 | Dual 1-of-4 Decoder/Demultiplexer | X | X | X | | |
| 54AC/74AC151 | 8-Input Multiplexer | X | X | X | | |
| 74ACT151 | 8-Input Multiplexer | X | | | | |
| 54AC/74AC153 | Dual 4-Input Multiplexer | X | X | X | | |
| 54ACT/74ACT153 | Dual 4-Input Multiplexer | X | X | X | | |
| 74AC157 | Quad 2-Input Multiplexer | X | | | | |
| 74ACT157 | Quad 2-Input Multiplexer | X | | | | |
| 74AC158 | Quad 2-Input Multiplexer | X | | | | |
| 74ACT158 | Quad 2-Input Multiplexer | X | | | | |
| 74ACT161 | 4-Bit Binary Counter | X | | | | |
| 74AC163 | 4-Bit Binary Counter | X | | | | |
| 74ACT163 | 4-Bit Binary Counter | X | | | | |
| 74AC169 | 4-Bit Binary Counter | X | | | | |
| 54AC/74AC174 | Hex D Flip-Flop | X | X | X | | |
| 74ACT174 | Hex D Flip-Flop | X | | | | |
| 74ACT175 | Quad D Flip-Flop | X | | | | |
| 74AC191 | 4-Bit Decade Counter | X | | | | |
| 54AC/74AC240 | Octal Buffer/Line Driver | X | | X | | |
| 74ACT240 | Octal Buffer/Line Driver | X | | | | |
| 54AC/74AC241 | Octal Buffer/Line Driver | X | | X | | |
| 74ACT241 | Octal Buffer/Line Driver | X | | | | |
| 54AC/74AC244 | Octal Buffer/Line Driver | X | | X | | |
| 74ACT244 | Octal Buffer/Line Driver | X | | | | |
| 54AC/74AC245 | Octal Bus Transceiver | X | X | X | | |
| 54ACT/74ACT245 | Octal Bus Transceiver | X | X | X | | |
| 54AC/74AC251 | 8-Input Multiplexer | X | X | X | | |
| 54AC/74AC253 | Dual 4-Input Multiplexer | X | X | X | | |

## Surface-Mount Device Index (Continued)

### Standard Logic—FACT (Continued)

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| 54ACT/74ACT253 | Dual 4-Input Multiplexer | X | X | X | | |
| 74ACT257 | Quad 2-Input Multiplexer | X | | | | |
| 74AC258 | Quad 2-Input Multiplexer | X | | | | |
| 74ACT258 | Quad 2-Input Multiplexer | X | | | | |
| 54AC/74AC273 | Octal D Flip-Flop | X | X | X | | |
| 54AC/74AC373 | Octal Latch | X | X | X | | |
| 54ACT/74ACT373 | Octal Latch | X | X | X | | |
| 54AC/74AC374 | Octal D Flip-Flop | X | X | X | | |
| 54ACT/74ACT374 | Octal D Flip-Flop | X | X | X | | |
| 74AC377 | Octal D Flip-Flop | X | | | | |
| 54ACT/74ACT377 | Octal D Flip-Flop | X | X | X | | |
| 54AC/74AC540 | Octal Buffer/Line Driver | X | X | X | | |
| 74AC541 | Octal Buffer/Line Driver | X | | | | |
| 74AC563 | Octal D Latch | X | | | | |
| 74ACT564 | Octal D Flip-Flop | X | | | | |
| 74AC573 | Octal D Latch | X | | | | |
| 74ACT574 | Octal D Flip-Flop | X | | | | |
| 74AC646 | Octal Bus Transceiver w/Register | X | | | | |
| 74AC648 | Octal Bus Transceiver w/Register | X | | | | |

### Standard Logic—FAST

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| 54F/74F00 | Quad 2-Input NAND Gate | X | X | X | | |
| 54F/74F02 | Quad 2-Input NOR Gate | X | X | X | | |
| 54F/74F04 | Hex Inverter Gate | X | X | X | | |
| 54F/74F08 | Quad 2-Input AND Gate | X | X | X | | |
| 54F/74F10 | Triple 3-Input NAND Gate | X | X | X | | |
| 54F/74F11 | Triple 3-Input AND Gate | X | X | X | | |
| 54F/74F20 | Dual 4-Input NAND Gate | X | X | X | | |
| 74F27 | Triple 3-Input NOR Gate | X | | | | |
| 74F30 | 8-Input NAND Gate | X | | | | |
| 54F/74F32 | Quad 2-Input OR Gate | X | X | X | | |
| 54F/74F38 | Quad 2-Input Buffer | X | X | X | | |
| 74F40 | Dual 4-Input Buffer | X | | | | |
| 74F51 | AND/OR-Invert Gate | X | | | | |
| 54F/74F64 | 4-2-3-2 Input AND/OR-Invert Gate | X | X | X | | |
| 54F/74F74 | Dual D Flip-Flop | X | X | X | | |
| 54F/74F86 | Quad 2-Input Exclusive-OR Gate | X | X | X | | |
| 54F/74F109 | Dual J-K Flip-Flop | X | X | X | | |
| 74F112 | Dual J-K Flip-Flop | X | | | | |
| 74F113 | Dual J-K Flip-Flop | X | | | | |
| 74F114 | Dual J-K Flip-Flop | X | | | | |

# Surface-Mount Device Index (Continued)

## Standard Logic—FAST (Continued)

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| 74F125 | Buffer | X | | | | |
| 54F/74F138 | 1-of-8 Decoder/Demultiplexer | X | X | X | | |
| 54F/74F139 | Dual 1-of-4 Decoder/Demultiplexer | X | X | X | | |
| 74F148 | 8-to-3 Priority Encoder | X | | | | |
| 54F/74F151A | 8-Input Multiplexer | X | X | X | | |
| 54F/74F153 | Dual 4-Input Multiplexer | X | X | X | | |
| 54F/74F157A | Quad 2-Input Multiplexer | X | X | X | | |
| 54F/74F158A | Quad 2-Input Multiplexer | X | X | X | | |
| 54F/74F160A | 4-Bit BCD Decade Counter | X | X | X | | |
| 54F/74F161A | 4-Bit Binary Counter | X | X | X | | |
| 54F/74F162A | 4-Bit BCD Decade Counter | X | X | X | | |
| 54F/74F163A | 4-Bit Binary Counter | X | X | X | | |
| 54F/74F164 | 8-Bit Shift Register | X | X | X | | |
| 74F168 | 4-Bit BCD Decade Counter | X | | | | |
| 74F169 | 4-Bit Binary Counter | X | | | | |
| 54F/74F174 | Hex D Flip-Flop | X | X | X | | |
| 54F/74F175 | Quad D Flip-Flop | X | X | X | | |
| 54F181 | ALU | | X | X | | |
| 74F182 | Carry Lookahead Generator | X | | | | |
| 54F/74F189 | 16 × 4-Bit RAM | X | X | X | | |
| 54F/74F190 | 4-Bit BCD Decade Counter | X | X | X | | |
| 54F/74F191 | 4-Bit Binary Counter | X | X | X | | |
| 54F/74F192 | 4-Bit BCD Decade Counter | X | X | X | | |
| 54F/74F193 | 4-Bit Binary Counter | X | X | X | | |
| 54F/74F194 | 4-Bit Bidirectional Shift Register | X | X | X | | |
| 54F/74F219 | 16 × 4-Bit RAM | X | X | X | | |
| 54F/74F240 | 8-Bit Inverting Buffer | X | X | X | | |
| 54F/74F241 | 8-Bit Noninverting Buffer | X | X | X | | |
| 54F/74F243 | Quad Bus Transceiver | X | X | X | | |
| 54F/74F244 | 8-Bit Noninverting Buffer | X | X | X | | |
| 54F/74F245 | Octal Bus Transceiver | X | X | X | | |
| 54F/74F251A | 8-Input Multiplexer | X | X | X | | |
| 54F/74F253 | Dual 4-Input Multiplexer | X | X | X | | |
| 54F/74F257A | Quad 2-Input Multiplexer | X | X | X | | |
| 54F/74F258A | Quad 2-Input Multiplexer | X | X | X | | |
| 54F/74F280 | Parity Checker/Generator | X | X | X | | |
| 54F/74F283 | Binary Full Adder, Lookahead | X | X | X | | |
| 74F299 | 8-Bit Octal Storage | X | | | | |
| 54F/74F322 | 8-Bit Parallel Shift Register | X | | X | | |
| 74F323 | 8-B torage Register | X | | | | |
| 74F350 | 4-Bit Shifter | X | | | | |
| 54F/74F352 | Dual 4-Input Multiplexer | X | X | X | | |
| 54F/74F353 | Dual 4-Input Multiplexer | X | X | X | | |
| 54F/74F365 | Hex Buffer/Driver | X | X | X | | |

# Surface-Mount Device Index (Continued)

## Standard Logic—FAST (Continued)

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| 54F/74F373 | Transparent Latch | X | X | X | | |
| 54F/74F374 | Octal, 3-State Output Flip-Flop | X | X | X | | |
| 54F/74F378 | Hex Parallel D Register | X | X | X | | |
| 54F/74F379 | Quad Parallel D Register | X | X | X | | |
| 74F381 | ALU/Function Generator | X | | | | |
| 74F382 | Carry Lookahead Generator | X | | | | |
| 54F/74F385 | Quad Adder/Subtractor, Reset | X | X | X | | |
| 54F/74F398 | Quad 2-Port Register | X | X | X | | |
| 54F/74F399 | Quad 2-Port Register | X | X | X | | |
| 74F401 | Cyclic Redundancy Checker-Generator | X | | | | |
| 54F/74F402 | Cyclic Redundancy Checker-Generator | X | X | X | | |
| 54F403 | 16 × 4 FIFO | | X | X | | |
| 54F407 | Data Access Register | | X | X | | |
| 74F410 | Register Stack | X | | | | |
| 54F/74F412 | Latch | | | X | | |
| 74F413 | 16 × 4 FIFO | X | | | | |
| 54F/74F521 | Identity Comparator | X | X | X | | |
| 74F524 | Magnitude OR Complement Comparator | X | | | | |
| 54F/74F533 | Inverting Transparent Latch | X | X | X | | |
| 54F/74F534 | Octal D Flip-Flop | X | X | X | | |
| 74F537 | 1-of-10 Decoder/Demultiplexer | X | | | | |
| 74F538 | 1-of-8 Decoder/Demultiplexer | X | | | | |
| 74F539 | Dual 1-of-4 Decoder/Demultiplexer | X | | | | |
| 54F/74F540 | Octal Buffer/Line Driver | X | X | X | | |
| 74F541 | Octal Buffer/Line Driver | X | | | | |
| 74F543 | Octal Registered Transceiver | X | | | | |
| 54F544 | Octal Registered Transceiver | | X | X | | |
| 54F/74F545 | Octal Bus Transceiver | X | | X | | |
| 54F/74F547 | 3-to-8 Decoder/Demultiplexer | X | X | X | | |
| 54F/74F548 | 3-to-8 Decoder/Demultiplexer | X | X | X | | |
| 54F/74F563 | Latch | X | X | X | | |
| 54F/74F564 | Octal D Flip-Flop | X | X | X | | |
| 74F568 | 4-Bit BCD Decade Counter | X | | | | |
| 74F569 | 4-Bit Binary Counter | X | | | | |
| 54F/74F573 | Latch | X | X | X | | |
| 54F574 | Octal D Flip-Flop | | X | X | | |
| 54F/74F583 | BCD Adder, Lookahead | X | | X | | |
| 74F588 | Octal Bidirectional Transceiver | X | | | | |
| 74F657 | Octal Transceiver with Parity | X | | | | |
| 54F676 | 16-Bit Serial Shift Register | | | X | | |

# Surface-Mount Device Index (Continued)

## Standard Logic—Field Programmable Logic Arrays

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| F93Z459 | 16 × 48 × FPLA |  | X | X |  |  |

## Standard Logic—Low-Power Schottky

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| 54LS00 | Quad 2-Input NAND Gate |  | X | X |  |  |
| 54LS02 | Quad 2-Input NOR Gate |  | X | X |  |  |
| 54LS03 | Quad 2-Input NAND Gate |  |  | X |  |  |
| 54LS04 | Hex Inverter Gate |  | X | X |  |  |
| 54LS05 | Hex Inverter Gate |  |  | X |  |  |
| 54LS08 | Quad 2-Input AND Gate |  | X | X |  |  |
| 54LS09 | Quad 2-Input AND gate |  |  | X |  |  |
| 54LS10 | Triple 3-Input NAND Gate |  | X | X |  |  |
| 54LS11 | Triple 3-Input AND Gate |  | X | X |  |  |
| 54LS13 | Dual 4-Input Schmitt Trigger Gate |  | X | X |  |  |
| 54LS14 | Hex Schmitt Trigger Gate |  | X | X |  |  |
| 54LS15 | Triple 3-Input AND Gate |  |  | X |  |  |
| 54LS20 | Dual 4-Input NAND Gate |  | X | X |  |  |
| 54LS21 | Dual 4-Input AND Gate |  | X | X |  |  |
| 54LS22 | Dual 4-Input NAND Gate |  |  | X |  |  |
| 54LS26 | Quad 2-Input NAND Gate |  |  | X |  |  |
| 54LS27 | Triple 3-Input NOR Gate |  | X | X |  |  |
| 54LS28 | Quad 2-Input NOR Gate |  | X | X |  |  |
| 54LS30 | 8-Input NAND Gate |  | X | X |  |  |
| 54LS32 | Quad 2-Input OR Gate |  | X | X |  |  |
| 54LS33 | Quad 2-Input NOR Gate |  |  | X |  |  |
| 54LS37 | Quad 2-Input NAND Buffer Gate |  | X | X |  |  |
| 54LS38 | Quad 2-Input NAND Buffer Gate |  |  | X |  |  |
| 54LS40 | Dual 4-Input NAND Buffer Gate |  | X | X |  |  |
| 54LS42 | 1-of-10 Decoder/Demultiplexer |  |  | X |  |  |
| 54LS47 | BCD to 7-Segment Decoder/Driver |  |  | X |  |  |
| 54LS48 | BCD to 7-Segment Decoder/Driver |  |  | X |  |  |
| 54LS49 | BCD to 7-Segment Decoder/Driver |  |  | X |  |  |
| 54LS51 | Dual 2-2 AND/OR-Invert Gate |  | X | X |  |  |
| 54LS54 | 2-2-3-3 AND/OR-Invert Gate |  |  | X |  |  |
| 54LS55 | 4-4 AND/OR-Invert Gate |  |  | X |  |  |
| 54LS74A | Dual D Flip-Flop |  | X | X |  |  |
| 54LS83A | 4-Bit Binary Full Adder w/Carry |  |  | X |  |  |
| 54LS85 | 4-Bit Magnitude Comparator |  | X | X |  |  |
| 54LS95B | 4-Bit Shift Register |  |  | X |  |  |
| 54LS109 | Dual J-K Flip-Flop |  |  | X |  |  |

## Surface-Mount Device Index (Continued)

### Standard Logic—Low-Power Schottky (Continued)

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| 54LS112 | Dual J-K Flip-Flop | | X | X | | |
| 54LS113 | Dual J-K Flip-Flop | | X | X | | |
| 54LS114 | Dual J-K Flip-Flop | | X | X | | |
| 54LS125A | Quad Buffer | | X | X | | |
| 54LS126 | Quad Buffer | | | X | | |
| 54LS133 | 13-Input NAND Gate | | X | X | | |
| 54LS136 | Quad 2-Input Exclusive-OR Gate | | | X | | |
| 54LS138 | 1-of-8 Decoder/Demultiplexer | | X | X | | |
| 54LS139 | Dual 1-of-4 Decoder/Demultiplexer | | X | X | | |
| 54LS151 | 8-Input Multiplexer | | X | X | | |
| 54LS152 | 8-Input Multiplexer | | | X | | |
| 54LS153 | Dual 4-Input Multiplexer | | X | X | | |
| 54LS155 | Dual 1-of-4 Decoder/Demultiplexer | | X | X | | |
| 54LS156 | Dual 1-of-4 Decoder/Demultiplexer | | | X | | |
| 54LS157 | Quad 2-Input Multiplexer | | X | X | | |
| 54LS158 | Quad 2-Input Multiplexer | | X | X | | |
| 54LS160A | BCD Decade Counter | | X | X | | |
| 54LS161A | 4-Bit Binary Counter | | X | X | | |
| 54LS162A | BCD Decade Counter | | X | X | | |
| 54LS163A | 4-Bit Binary Counter | | X | X | | |
| 54LS164 | 8-Bit Shift Register | | X | X | | |
| 54LS165 | 8-Bit Shift Register | | | X | | |
| 54LS168 | BCD Decade Up/Down Counter | | X | X | | |
| 54LS169 | 4-Bit Binary Up/Down Counter | | X | X | | |
| 54LS170 | 16-Bit D Latch | | | X | | |
| 54LS173 | Quad D Register | | X | X | | |
| 54LS174 | Hex D Flip-Flop | | X | X | | |
| 54LS175 | Quad D Flip-Flop | | X | X | | |
| 54LS181 | 4-Bit ALU | | | X | | |
| 54LS192 | BCD Decade Up/Down Counter | | X | X | | |
| 54LS193 | 4-Bit Binary Up/Down Counter | | X | X | | |
| 54LS194A | 4-Bit Bidirectional Shift Register | | X | X | | |
| 54LS195A | 4-Bit Shift Register | | X | X | | |
| 54LS240 | Octal Inverting Bus Driver | | X | X | | |
| 54LS241 | Octal Noninverting Bus Driver | | X | X | | |
| 54LS244 | Octal Noninverting Bus Driver | | X | X | | |
| 54LS245 | Octal Bus Transceiver | | X | X | | |
| 54LS247 | BCD to 7-Segment Decoder/Driver | | | X | | |
| 54LS248 | BCD to 7-Segment Decoder/Driver | | | X | | |
| 54LS249 | BCD to 7-Segment Decoder/Driver | | | X | | |

# Surface-Mount Device Index (Continued)

## Standard Logic—Low-Power Schottky (Continued)

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| 54LS251 | 8-Input Multiplexer | | | X | | |
| 54LS253 | Dual 4-Input Multiplexer | | X | X | | |
| 54LS256 | Dual 4-Bit Address Latch | | | X | | |
| 54LS257A | Quad 2-Input Multiplexer | | X | X | | |
| 54LS258A | Quad 2-Input Multiplexer | | X | X | | |
| 54LS259 | 8-Bit Address Latch | | X | X | | |
| 54LS260 | Dual 5-Input NOR Gate | | X | X | | |
| 54LS266 | Quad 2-Input Exclusive-NOR Gate | | | X | | |
| 54LS273 | Octal D Register | | X | X | | |
| 54LS279 | 4-Bit RS Latch | | X | X | | |
| 54LS283 | 4-Bit Binary Full Adder w/Carry | | | X | | |
| 54LS295A | 4-Bit Shift Register | | | X | | |
| 54LS298 | Quad 2-Port Register | | | X | | |
| 54LS299 | 8-Bit Shift Register | | X | X | | |
| 54LS322 | 8-Bit Shift Register | | | X | | |
| 54LS323 | 8-Bit Shift Register | | | X | | |
| 54LS347 | BCD to 7-Segment Decoder/Driver | | | X | | |
| 54LS352 | Dual 4-Input Multiplexer | | | X | | |
| 54LS353 | Dual 4-Input Multiplexer | | | X | | |
| 54LS365A | Hex Buffer Gate | | X | X | | |
| 54LS366A | Hex Inverter Gate | | X | X | | |
| 54LS367A | Hex Buffer Gate | | X | X | | |
| 54LS368A | Hex Inverter Gate | | X | X | | |
| 54LS374 | Octal D Flip-Flop | | X | X | | |
| 54LS375 | 4-Bit D Latch | | | X | | |
| 54LS377 | Octal D Flip-Flop | | X | X | | |
| 54LS378 | Hex Parallel D Register | | | X | | |
| 54LS379 | Quad Parallel D Register | | X | X | | |
| 54LS395 | 4-Bit Shift Register | | X | X | | |
| 54LS447 | BCD to 7-Segment Decoder/Driver | | | X | | |
| 54LS490 | Dual 2 × 5 Counter | | | X | | |
| 54LS502 | 8-Bit Successive Approximation Register | | | X | | |
| 54LS503 | 8-Bit Successive Approximation Register | | | X | | |
| 54LS670 | 16-Bit D Latch | | X | X | | |
| 96LS02 | Dual Retriggerable Monostable Multivibrator | | | X | | |

## Surface-Mount Device Index (Continued)

### Standard Logic—TTL

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| 5400 | Quad 2-Input NAND Gate | | | X | | |
| 5402 | Quad 2-Input NOR Gate | | | X | | |
| 5404 | Hex Inverter NAND Gate | | | X | | |
| 5408 | Quad 2-Input AND Gate | | | X | | |
| 5409 | Quad 2-Input AND Gate | | | X | | |
| 5410 | Triple 3-Input NAND Gate | | | X | | |
| 5414 | Hex Schmitt Trigger NAND Gate | | | X | | |
| 5420 | Dual 4-Input NAND Gate | | | X | | |
| 5425 | Dual 4-Input NOR Gate | | | X | | |
| 5430 | 8-Input NAND Gate | | | X | | |
| 5432 | Quad 2-Input OR Gate | | | X | | |
| 5437 | Quad 2-Input Buffer Gate | | | X | | |
| 5440 | Dual 4-Input NAND Buffer | | | X | | |
| 5442A | 1-of-10 Decoder/Demultiplexer | | | X | | |
| 5451 | Dual 2-2 AND/OR-Invert Gate | | | X | | |
| 5473 | Dual J-K Flip-Flop | | | X | | |
| 5474 | Dual D Flip-Flop | | | X | | |
| 5475 | 4-Bit D Latch | | | X | | |
| 5476 | Dual J-K Flip-Flop | | | X | | |
| 5483A | 4-Bit Binary Full Adder w/Carry | | | X | | |
| 5485 | 4-Bit Magnitude Comparator | | | X | | |
| 5486 | Quad 2-Input Exclusive-OR Gate | | | X | | |
| 5490 | Decade Counter | | | X | | |
| 5495A | 4-Bit Shift Register | | | X | | |
| 5497 | Rate Multiplier | | | X | | |
| 54121 | Monostable Multivibrator | | | X | | |
| 54122 | Retriggerable Monostable Multivibrator | | | X | | |
| 54123 | Dual Retriggerable Monostable Multivibrator | | | X | | |
| 54125 | Quad Bus Buffer | | | X | | |
| 54150 | 16-Input Multiplexer | | | X | | |
| 54151A | 8-Input Multiplexer | | | X | | |
| 54153 | Dual 4-Input Multiplexer | | | X | | |
| 54154 | 1-of-16 Decoder/Demultiplexer | | | X | | |
| 54157 | Quad 2-Input Multiplexer | | | X | | |
| 54161 | Binary Counter | | | X | | |
| 54164 | 8-Bit Shift Register | | | X | | |
| 54165 | 8-Bit Shift Register | | | X | | |
| 54170 | 4 × 4 Register File (16-Bit D Latch) | | | X | | |
| 54173 | 4-Bit D Register | | | X | | |
| 54174 | Hex D Flip-Flop | | | X | | |
| 54175 | Quad D Flip-Flop | | | X | | |
| 54191 | Up/Down Binary Counter | | | X | | |
| 54279 | 4-Bit RS Latch | | | X | | |
| 54283 | Full Binary Adder w/Carry | | | X | | |

# Surface-Mount Device Index (Continued)

## Standard Logic—TTL (Continued)

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| 54298 | Quad 2-Port Register | | | X | | |
| 9300 | 4-Bit Universal Shift Register | | | X | | |
| 9301 | 1-of-10 Decoder/Demultiplexer | | | X | | |
| 9308 | Dual 4-Bit D Latch | | | X | | |
| 9309 | Dual 4-Input Multiplexer | | | X | | |
| 9311 | 1-of-16 Decoder/Demultiplexer | | | X | | |
| 9312 | 8-Input Multiplexer | | | X | | |
| 9314 | Quad 4-Bit D Latch | | | X | | |
| 9316 | 4-Bit Binary Counter | | | X | | |
| 9321 | Dual 1-of-4 Decoder/Demultiplexer | | | X | | |
| 9322 | Quad 2-Input Multiplexer | | | X | | |
| 9324 | 5-Bit Magnitude Comparator | | | X | | |
| 9328 | Dual Serial 8-Bit Shift Register | | | X | | |
| 9334 | 8-Bit Address Latch | | | X | | |
| 9338 | 8-Bit Multiple Port Register | | | X | | |
| 9348 | 12-Bit Parity Checker/Generator | | | X | | |
| 9601 | Retriggerable Monostable Multivibrator | | | X | | |
| 9602 | Dual Retriggerable Monostable Multivibrator | | | X | | |

## Standard Logic—Low Power TTL

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| 93L00 | 4-Bit Universal Shift Register | | | X | | |
| 93L01 | 1-of-10 Decoder/Demultiplexer | | | X | | |
| 93L08 | Dual 4-Bit D Latch | | | X | | |
| 93L10 | BCD Decade Counter | | | X | | |
| 93L12 | 8-Input Multiplexer | | | X | | |
| 93L14 | 4-Bit Latch | | | X | | |
| 93L21 | Dual 1-of-4 Decoder/Demultiplexer | | | X | | |
| 93L22 | Quad 2-Input Multiplexer | | | X | | |
| 93L24 | 5-Bit Magnitude Comparator | | | X | | |
| 93L28 | Dual Serial 8-Bit Shift Register | | | X | | |
| 93L34 | 1-of-8 Decoder/Demultiplexer | | | X | | |
| 93L38 | Multiple Port Register | | | X | | |
| 96L02 | Dual Retriggerable Monostable | | | X | | |

## Surface-Mount Device Index (Continued)

### Standard Logic—High-Speed ECL

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| F100101 | Triple 5-Input OR/NOR Gate |  | X | X |  |  |
| F100102 | Quint 2-Input OR/NOR Gate |  | X | X |  |  |
| F100104 | Quint 2-Input AND/NAND Gate |  |  | X |  |  |
| F100107 | Quint Exclusive-OR/NOR Gate |  | X | X |  |  |
| F100112 | Quad Line Driver |  | X | X |  |  |
| F100113 | Quad Line Driver |  | X | X |  |  |
| F100114 | Quint Differential Line Receiver |  | X | X |  |  |
| F100117 | Triple 2-Wide OR-NOR/AND-NAND Gate |  | X | X |  |  |
| F100118 | 5-Wide 5, 4, 4, 4, 2 OA/OAI Gate |  | X | X |  |  |
| F100121 | 9-Bit Inverter Gate |  | X | X |  |  |
| F100122 | 9-Bit Buffer |  | X | X |  |  |
| F100123 | Hex Bus Driver |  |  | X |  |  |
| F100124 | Hex TTL-to-ECL Translator |  |  | X |  |  |
| F100125 | Hex ECL-to-TTL Translator |  |  | X |  |  |
| F100126 | 9-Bit Backplane Driver |  |  | X |  |  |
| F100128 | ECL/TTL Bidirectional Translator |  |  | X |  |  |
| F100130 | Triple D Latch |  |  | X |  |  |
| F100131 | Triple D Flip-Flop |  |  | X |  |  |
| F100135 | Triple J-K Flip-Flop |  |  | X |  |  |
| F100136 | 4-Bit Bidirectional Shift Register |  |  | X |  |  |
| F100141 | 8-Bit Bidirectional Shift Register |  |  | X |  |  |
| F100142 | 4 × 4 Content-Addressable Memory |  |  | X |  |  |
| F100145 | 16 × 4 Register File |  |  | X |  |  |
| F100150 | Hex D Latch |  |  | X |  |  |
| F100151 | Hex D Flip-Flop |  |  | X |  |  |
| F100155 | Quad Multiplexer/Latch |  | X | X |  |  |
| F100156 | Merge-Mask Latch |  |  | X |  |  |
| F100158 | 8-Bit Shift Matrix |  |  | X |  |  |
| F100160 | Dual Parity Checker/Generator |  | X | X |  |  |
| F100163 | Dual 8-Input Multiplexer |  | X | X |  |  |
| F100164 | 16-Input Multiplexer |  | X | X |  |  |
| F100165 | Universal Priority Encoder |  | X | X |  |  |
| F100166 | 9-Bit Comparator |  | X | X |  |  |
| F100170 | 1-of-8/Dual 1-of-4 Demux/Decoder |  | X | X |  |  |
| F100171 | Triple 4-Input Multiplexer |  |  | X |  |  |
| F100179 | Carry Lookahead Generator |  |  | X |  |  |
| F100180 | High-Speed 6-Bit Adder |  | X | X |  |  |
| F100181 | 4-Bit Binary/BCD ALU |  |  | X |  |  |
| F100182 | 9-Bit Wallace Tree Adder |  |  | X |  |  |
| F100183 | 2 × 8-Bit Recode Multiplier |  |  | X |  |  |
| F100250 | Quint Line Transceiver |  |  | X |  |  |
| F100402 | 16 × 4 Register File |  |  | X |  |  |

# Surface-Mount Device Index (Continued)

## Standard Logic—F11C ECL

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| 11C01 | Dual 5-4 Input OR/NOR Gate | | | X | | |
| 11C05 | 1 GHz Divide by-4 Counter | | | X | | |

## Application Specific ICs—FGE Series

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| FGE0050 | 100-Gate Equivalent | | | X | | |
| FGE0500 | 680-Gate Equivalent | | X | | | |

## Memory

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| **Bipolar Static RAMs (ECL I/O)** | | | | | | |
| F10145A | 16 × 4-Bit Register File | | | X | | |
| F10402 | 16 × 4-Bit Register File | | | X | | |
| F10415 | 1024 × 4-Bit | | | X | | |
| F10422 | 256 × 4-Bit | | | X | | |
| F10474 | 1024 × 4-Bit | | | X | | |
| F10545 | 16 × 4-Bit Register File | | | X | | |
| F100145 | 16 × 4-Bit Register File | | X | X | | |
| F100402 | 16 × 4-Bit Register File | | | X | | |
| F100415 | 1024 × 1-Bit | | | X | | |
| F100422 | 256 × 4-Bit | | | X | | |
| F100474 | 1024 × 4-Bit | | | X | | |
| **BiCMOS Static RAMs (ECL I/O)** | | | | | | |
| F10490 | 64K × 1 | | | X | | |
| F10494 | 16K × 4 | | | X | | |
| F10500 | 256K × 1 | | | X | | |
| F10504 | 64K × 4 | | | X | | |
| F100490 | 64K × 1 | | | X | | |
| F100494 | 16K × 4 | | | X | | |
| F100500 | 256K × 1 | | | X | | |
| F100504 | 64K × 4 | | | X | | |

# Surface-Mount Device Index (Continued)

## Memory (Continued)

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| **TTL Static RAMs** | | | | | | |
| F93415 | 1024 × 1-Bit | | | X | | |
| F93415A | 1024 × 1-Bit | | | X | | |
| F93L415 | 1024 × 1-Bit | | | X | | |
| F93422 | 256 × 4-Bit | | X | X | | |
| F93422A | 256 × 4-Bit | | X | X | | |
| F93L422 | 256 × 4-Bit | | X | X | | |
| F93L422A | 256 × 4-Bit | | X | X | | |
| F93425 | 1024 × 1-Bit | | X | X | | |
| F93425A | 1024 × 1-Bit | | X | X | | |
| F93L425 | 1024 × 1-Bit | | X | X | | |
| F93479 | 256 × 9-Bit | | X | X | | |
| F93479A | 256 × 9-Bit | | X | X | | |
| **Bipolar PROMs (TTL I/O)** | | | | | | |
| F93Z451 | 1024 × 8-Bit | | X | X | | |
| F93Z451A | 1024 × 8-Bit | | X | X | | |
| F93Z511 | 2048 × 8-Bit | | X | X | | |
| F93Z565 | 8196 × 8-Bit | | X | | | |
| F93Z565A | 8196 × 8-Bit | | X | | | |
| F93Z665 | 8196 × 8-Bit | | X | | | |
| **CMOS Static RAMs (TTL I/O)** | | | | | | |
| F1600A | 64K × 1-Bit | | X | | | |
| F1601A | 64K × 1-Bit | | X | | | |
| F1620 | 16K × 4-Bit | | X | | | |
| F1621 | 16K × 4-Bit | | X | | | |
| F1622 | 16K × 4-Bit | | X | | | |
| F1623 | 16K × 4-Bit | | X | | | |

# Surface-Mount Device Index (Continued)

## Linear

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| **Operational Amplifiers** | | | | | | |
| μA301A | General-Purpose | X | | | | |
| μA308, A | Super Beta | X | | | | |
| μA324 | Quad | X | | | | |
| μA709C | High-Performance | X | | | | |
| μA714 | Precision | X | | | | |
| μA741 | High-Performance | X | | | | |
| μA747 | General-Purpose | X | | | | |
| μA748 | High-Performance | X | | | | |
| μA771 | JFET | X | | | | |
| μA772 | JFET | X | | | | |
| μA774 | JFET | X | | | | |
| μA798 | Dual | X | | | | |
| μA1458 | High-Performance | X | | | | |
| μA3403 | Quad | X | | | | |
| μA4136 | Quad | X | | | | |
| **Comparators** | | | | | | |
| μA239 | Quad | X | | | | |
| μA311 | Voltage | X | | | | |
| μA339 | Quad | X | | | | |
| μA3302 | Quad | X | | | | |
| μA685 | High-Speed | X | | | | |
| μA6685 | Ultra-Fast | X | | | | |
| **Special Function** | | | | | | |
| μA555 | Single Timer | X | | | | |
| μA592 | Differential Video Amplifier | X | | | | |
| μA733 | Differential Video Amplifier | X | | | | |
| μA3046 | Transistor Array | X | | | | |
| μA3086 | Transistor Array | X | | | | |
| μA3680 | Quad Telephone Relay Driver | X | | | | |

# Surface-Mount Device Index (Continued)

## Linear (Continued)

| Device | Function | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|---|
| **Voltage Regulators** | | | | | | |
| μA109 | 3-Terminal | X | | | | |
| μA117 | 3-Terminal | X | | | | |
| μA138 | 5-Amp | X | | | | |
| μA150 | 3-Amp | X | | | | |
| μA209 | 3-Terminal | X | | | | |
| μA217 | 3-Terminal | X | | | | |
| μA238 | 5-Amp | X | | | | |
| μA250 | 3-Amp | X | | | | |
| μA309 | 3-Terminal | X | | | | |
| μA317 | 3-Terminal | X | | | | |
| μA338 | 5-Amp | X | | | | |
| μA350 | 3-Amp | X | | | | |
| μA7805 | 3-Terminal | X | | | | |
| μA7815 | 3-Terminal | X | | | | |
| μA7824 | 3-Terminal | X | | | | |
| μA78L05 | 3-Terminal | X | | | | |
| μA7905 | 3-Terminal | X | | | | |
| μA7908 | 3-Terminal | X | | | | |
| μA7912 | 3-Terminal | X | | | | |
| μA7915 | 3-Terminal | X | | | | |
| μA431A | Adjustable Precision | X | | | | |

## Interface Products

| | | |
|---|---|---|
| μA1488 | Quad Line Driver, RS-232 | X |
| μA1489 | Quad Line Receiver, RS-232 | X |
| μA9637A | Dual Differential Line Receiver | X |
| μA9638 | Dual Differential Line Driver | X |
| μA75107A, B | Dual Line Receiver | X |
| μA75108B | Dual Line Receiver | X |
| μA75110A | Dual Line Driver | X |
| μA75150 | Dual Line Driver | X |
| μA75176 | Differential Transceiver | X |
| μA75177 | Differential Repeater | X |
| μA75178 | Differential Repeater | X |
| μA75451A | Dual Positive AND Driver | X |
| μA75452A | Dual Positive NAND Driver | X |
| μA75453A | Dual Positive OR Driver | X |
| μA96176A | Differential Transceiver | X |
| μA96177A | Differential Receiver | X |
| μA96178A | Differential Receiver | X |

# Surface-Mount Device Index (Continued)

## Power and Discrete

| Device | SOIC | LCC | FLAT | SOT | MELF |
|---|---|---|---|---|---|
| Leadless Small Signal Diodes | | | | | X |
| Small Signal Diodes | | | | X | |
| Monolithic Diode Arrays | X | | X | | |
| Small Signal Transistors | | | | X | |
| Quad Transistors | X | | | | |

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Section 3

# New Product Updates for 1988

# Advanced Peripherals

For additional Advanced Peripheral products, see page 1.

# New Graphics Processor from National Offers Highest Performance, Flexible Design

National Semiconductor Corporation has announced availability of the DP8500 Raster Graphics Processor (RGP), a high-speed, programmable processor for bitmapped graphics systems. The new chip joins National's Advanced Graphics Chip Set (AGCS), a family of very large-scale integrated (VLSI) building blocks for a wide range of high-performance video graphics and printer applications.

The RGP is the fastest component of its type on the market. The 20-megahertz complementary metal-oxide semi-conductor (CMOS) chip features a 100-nanosecond bus cycle time on back-to-back vector and block operations. The chip dramatically boosts the rendering speed of graphics operations and also controls video refresh function.

"The need for greater resolution. richer colors and faster graphics performance is a major competitive force in the computer systems market today," said Roger Reak, director of graphics marketing. "The RGP and other AGCS chips provide the highest level of graphics performance and resolution available on commercial chips. Yet their pricing and modular architecture make them cost-effective for low- and high-end systems alike, from personal computers to sophisticated workstations."

One of the RGP's advantages is its coupling of flexibility and speed. Like special-purpose, fixed-function chips, the RGP has hard-wired high-performance circuitry for graphics operations such as line drawing, fill and parallel clipping. On the other hand, the chip also offers the programmability typical of general-purpose processors. Programmability enables manufacturers to differentiate their products through proprietary algorithms and to optimize them for particular applications in engineering, business and desktop publishing.

The Advanced Graphics Chip Set provides an architecture adaptable enough to support whole families of graphics products that include a range of price and performance options. Users of the chip set can build on the AGCS architecture as new graphics components emerge and as system requirements evolve. Together with the chips' industry-leading performance, this architectural openness supports long-lived product lines.

Suitable applications for the RGP and other AGCS chips include high-performance graphics boards for personal computers, graphics sub-systems for engineering workstations, and rasterization engines for laser printers and other high-resolution hard-copy devices. The chips are capable of supporting the highest resolution devices with performance that is independent of color depth.

The RGP works with all types of memory, allowing designers to tailor the overall processing speed and control system cost through the choice of memory device. The RGP can access frame buffers in both a planar or pixel fashion, with the two modes selectable on an operation-by-operation basis.

A full range of software tools from National is available for the RGP. In addition, Nova Graphics International of Austin, Texas, is providing full support for graphics software standards.

Samples of the DP8500 Raster Graphics Processor are available now, production quantities becoming available by the third quarter of 1988.

National Semiconductor's family of graphics chips provides a rich collection of graphics functions and gives designers the performance they need to build a wide range of graphics products featuring a common hardware and software core.

# Biphase Communications Processor Links IBM Mainframes To Office Computers

***The DP8344 Biphase Communications Processor allows systems designers to develop the next generation of highly integrated communication devices to improve the efficiency of peripheral-to-IBM mainframe communications.***

The DP8344 lowers the cost of implementing IBM 3270, 3299 and 5250 protocol communications capabilities and reduces the size and complexity of products designed to encode, decode and process the protocols. It can be easily integrated into cluster controllers, personal computers (PCs), terminals and printers to access IBM 370-class mainframes and IBM System 34/36/38 mid-frame/departmental computers.

The typical system implementation using the DP8344 requires only 64 square inches of space on a printed circuit board. Device designers combined the CPU and transceiver elements on one chip and integrated the functions of 30 MSI/LSI components to make the DP8344 compact, versatile and very fast.

## Eliminating System Microprocessors

The device features a 20-MHz, 50-nanosecond T-state processor with a minimum instruction-cycle time of 100 nanoseconds and a maximum instruction-cycle time of 200 nanoseconds. The processor is powerful enough to eliminate previously required system microprocessors because it typically requires only 20 percent of its bandwidth to service 3270 coax-polled commmands. Eighty percent of its processing power remains for other non-communications system tasks.

Additional processor features include direct access to 64K by 16-bit instruction memory, access to separate 64K by 8-bit data memory, 30 instruction types, a 16-bit timer and an arithmetic logic unit (ALU) and barrel shifter.

The transceiver section of the DP8344 is protocol-selectable through software and can support IBM 3270/3299 coax, 5250 twinax and general 8-bit protocols. The transceiver also features fully registered status and control capabilities and an on-chip CMOS differential line receiver.

## Power And Flexibility

The DP8344 brings power and flexibility to the IBM protocol communications environment. Because the DP8344's processor is general purpose, users can readily respond to changes in communication-protocol command content and sequences, and easily integrate the unit into current and future products.

The 20-MHz processor, fabricated with National's M$^2$CMOS process, features subroutine and interrupt capabilities, on-board address and data stacks, software-controlled waitstates for program and data memory and general-purpose bus interfacing with on-board arbitration logic capable of supporting all major CPUs and bus standards. It can operate together with a remote processor or in a stand-alone mode as the system host.

The transceiver's complete system interface for the three IBM protocols and general 8-bit protocol makes the physical IBM system connection uncomplicated. In addition to traditional IBM plug-compatible terminal and printer applications, the DP8344 can be used to "gateway" between the coax or twinax cabling world and various local area networks such as Ethernet, token ring, Arcnet and others.

The DP8344 can be installed on a communications card designed for a PC-expansion slot to provide a micro-to-mainframe link. The card lets the PC emulate a 3270- or 5250-type terminal, but the PC retains its distributed processing power. If a local area network (LAN) card is installed in the same PC, gateway capabilities can also be provided. Up to 40 mainframe sessions can be distributed to the LAN through the 3299 protocol conduit.

The DP8344 may also function as an IBM 3270-to-ASCII/ANSI protocol converter, giving inexpensive terminals access to powerful IBM mainframes.

## IBM Sets The Pace

Market trends and IBM's direction in data communications underscore the significance of the DP8344's introduction.

IBM's role in the data communications world, which is mainframe/mid-frame-oriented, greatly influences the future direction of the market. IBM will continue to support the 3270 and 5250 terminals as the primary connection vehicles to mainframes and medium-sized computers into the 1990s, according to Dataquest. The 3270 protocol, in particular, will remain a major standard for IBM host interactive communications.

Expanded media, connectivity and application program options for the 3270/5250 protocol environment are likely to be introduced by IBM. An example of this includes Advanced Program-to-Program Communication (APPC) in the 3270 environment, which would give users "peer-to-peer" LAN-like communications capabilities. Distributed Function Devices (DFDs) that will deliver more mainframe sessions to a greater number of intelligent peripherals, without increasing user costs, is another example.

The cost of 3270/5250 connectivity will continue to decline and approach today's price levels of RS232 connections in the 1990s. The protocols will become a communications standard for all products requiring access to IBM host-processing resources and applications programs.

## DP8344 Design Wins

The DP8344 already boasts an impressive list of over 100 design wins. Companies that have designed the chip into new products that are scheduled for shipment include Hewlett-Packard, Local Data, Pathway Designs, Capstone Technology, Centronics/Genicom, McData and Microplus.

Products designed with the DP8344 cover all major applications, including cluster controllers, terminals, printer interfaces, 3270-to-token ring gateways and terminal-emulation devices for the PC.

Hewlett-Packard is using the DP8344 in its recently announced 700/71 terminal, a plug-compatible alternative to the industry-standard 3191 terminal. It is their first release of a plug-compatible 3270-protocol product.

## Development Support Available

The DP8344 is backed by a full range of development tools and an extensive network of design centers.

Development tools available include a DP8344-based evaluation board kit with a monitor/debugger program, 3178 terminal demo software, a macro assembler with linker, and system development tools for line analysis and word generation/line stimulizers for coax/twinax product development and testing.

# World's Fastest Turbo Transceiver Introduced

***The fastest single-ended transceiver in the industry allows users to add a large number of printed circuit (PC) boards to a computer backplane with no degradation in system speed.***

Designed for use in systems with heavily loaded backplanes, the new DS3893 Turbotransceiver improves the performance of any synchronous or asynchronous bus. It features a typical driver-enable and receiver propagation delay of only 3.5 nanoseconds, and can drive densely loaded backplanes with equivalent load impedances down to 10 ohms. The bipolar unit meets the signaling characteristics of the BTL (backplane transceiver logic) standard, developed to improve the performance of backplane buses.

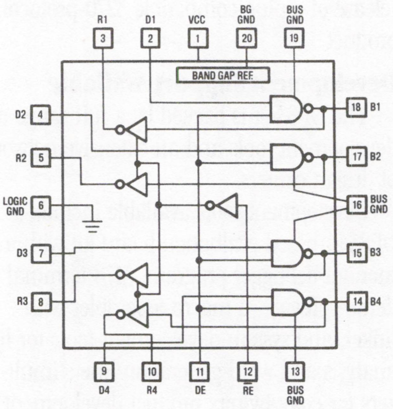
BTL-compatible transceivers feature a nominal 1-volt signal swing (1 volt low to 2 volts high) for low-power consumption, drivers with low-output capacitance to minimize bus-loading and receivers with very precise thresholds (1.47 to 1.62 volts) for maximum noise immunity. On the Turbotransceiver, a built-in bandgap reference assures the accuracy of the receiver threshold.

All of these features allow higher bus-transfer rates, improve overall system reliability and eliminate the "settling" time delays that severely limit TTL bus performance.

### IEEE 896: Futurebus Conformance

The DS3893 Turbotransceiver also conforms to the requirements of the IEEE 896 Futurebus standard, a proposed general-purpose bus standard for high-performance microcomputer systems. The Futurebus standard offers unmatched performance levels for multiple-processor and cache-based systems.

Other features of the DS3893 Turbotransceiver include a busport capacitance of less than 7 picofarads, high-impedance MOS- and TTL-compatible inputs, and TRI-STATE control for the receiver outputs.



# DRAM Controllers Drive Arrays To New Heights

***National introduces the first DRAM controller capable of directly addressing and driving 4-megabit DRAM arrays up to 64 megabytes.***

The DP8422 conroller/driver is versatile enough to be easily interfaced to all major 8-, 16- and 32-bit microprocessors without the need for previously required external support circuits.

The device offers users unmatched performance in terms of versatility, power, and addressing capabilities. Its programmability feature provides more flexibility than any current generation DRAM controller, and its support for two access ports simplifies applications requiring shared-memory access. The additional port allows a second CPU, DMA (Direct Memory Access), LAN (Local Area Network), or graphics controller access to the same memory bank.

### Partners In Performance

The DP8422, along with the new single-ported, 1-megabit DP8421 and 256K-bit DP8420 DRAM controller/drivers, is ideally suited for a wide variety of DRAM-based applications where high-performance, no wait-state memory access is essential.

Several speed-enhancing features, such as support for memory interleaving and Burst-Nibble, Page, and Static Column memory access modes, allow the DP8420/21/22 to reach performance levels achieved by the fastest previous generation of 1-megabit, bipolar DRAM controller/drivers–the DP8428/29s.

The integration of programmable, on-chip, wait-state logic and the elimination of previously required external support logic also aid in the improved performance level of these CMOs devices. In addition, a built-in, high-precision delay line that uses a high-speed Phase Lock Loop (PLL) significantly enhances the DP8420/21/22's performance by tightening critical timing parameters.

Four RAS drivers, four CAS drivers, WE (write enable) and the necessary address drivers are provided on chip. For DRAM-based applications employing error detection and correction, the DP8420/21/22 features scrubbing during refresh with on-chip row, column, and bank counters, as well as the required arbitration logic.

### Highly Programmable

The DP8420/21/22 DRAM controllers can easily be programmed to work with a variety of computer systems, regardless of DRAM access type. Adjustable control signal pulse widths allow use with the full spectrum of microprocessor/CPU operating frequencies, even beyond the 20 MHz boundary. Their programmable $t_{RAH}$ (Row Address Hold) and $T_{ASC}$ (Column Address Setup) times permit operation with fast or slow DRAMS.

In addition, they also allow programmable selection of RAS low time during refresh, the refresh time span, RAS precharge time, and the RAS/CAS configuration. A variety of refresh operations, including staggered and burst refresh, are automatic and transparent to the system.

### Total Integration

By using the most modern process techniques available, National has integrated all major features associated with the interface, control and drive functions of today's DRAMs. These include on-chip address latches, bank-select logic, arbitration logic to support shared-memory accessing (DP8422), wait-state logic, and an on-chip delay line and refresh counter. Also provided are a high-speed row/column/refresh multiplexer, access/refresh arbitration logic, an automatic on-chip column address incrementor and high-capacitive drivers.

National has complemented the DP8420/21/22s by packaging them in low-cost 68-pin and 84-pin PCC packages. The DP8420 and DP8421 are offered in 68-pin PCCs and the DP8422 in an 84-pin PCC.

# Video DRAM Controller/ Drivers Go Graphic

***The most versatile and powerful Video DRAM Controllers in the industry join National's Advanced Graphics Chip Set (AGCS).***

National's AGCS provides a new level of VLSI graphics performance for a wide range of CRT and hard-copy system designs. The new DP8520/21/22 programmable video DRAM controller/drivers can address and drive arrays 256K-bit, 1-megabit, or 4-megabit video DRAMs. The devices can be easily programmed to work with a variety of computer systems, regardless of video DRAM access type.

The DP8522 controller/driver directly addresses and drives an array of 4-megabit video DRAMs up to 64 megabytes in size. It easily interfaces to all major 8-, 16-, and 32-bit microprocessors, without the need for any external support circuits.

The DP8522's support for two access ports simplifies applications requiring shared-memory access by allowing two processors to address the same dual-ported memory component. Along with the new single-ported 1-megabit DP8521 and 256K-bit DP8520 video DRAM controller/drivers, the DP8522 is well-suited for a wide range of video DRAM-based applications where no-wait-state memory access is required.

**Active Transfer Cycles**

When the DP8520, DP8521 and DP8522 are used in a graphics frame buffer application, they are able to support a video DRAM transfer cycle during active video time. This is an extremely attractive feature supported by National's AGCS. Most commercially available graphics controller chip sets support video DRAM transfer cycles only during "video-blanking" periods (while the video DRAM is in standby mode).

Several speed-enhancing features allow the CMOS DP8520/21/22 devices to reach performance levels achieved by bipolar DRAM controller/drivers. These include support for memory interleaving and Burst/ Nibble, Page and Static Column memory access modes.

The DP8520 and DP8521 are offered in 68-pin PCCs and the DP8522 in an 84-pin PCC. Samples, designated DP8520V, DP8521V and DP8522V are available now.

# Multi-Board Clock System Boosts Color Graphics

***Two additions to National's Advanced Graphics Chip Set (AGCS) solve clock synchronization problems in high-performance color graphics systems.***

The DP8513 Video Clock Generator and the DP8514 Crystal Clock Generator form a multi-board clock system that puts virtually no limits on the allowable number of memory boards and color planes. The DP8513 has the identical features of the DP8512 Video Clock Generator (VCG), which is also designed for use in graphics systems.

Except for the reference-frequency input format, the DP8513 has the identical features of the DP8512 Video Clock Generator (VCG), which is also designed for use in graphics systems.

The device simplifies timing and minimizes phase skew between the various signals involved in the transfer of DRAM or video DRAM data into a D-to-A converter for display on a CRT. Used in conjunction with the DP8514, the Multi-Board Clock System employs digital phase-locked loop (PLL) techniques to originate a graphics processor clock, a raster-scan pixel clock, and a gated and non-gated load clock.

### Phase-Locked Graphics

The DP8513 features a 225 MHz ECL differential output pixel clock. A non-overlapping 2-phase MOS-compatible clock output, required for 20 MHz operation of a raster graphics processor, is also generated. An on-chip PLL allows the clocks to be locked to an external horizontal synch pulse so that the graphics system can be phase-locked to an outside video source. All clock rates are pin-programmable.

The TTL-compatible device accommodates video data word widths from 4 to 64 bits, in increments of 4 bits. Its ECL circuitry can be referenced to a positive or negative power supply, or a single-5 volt supply.

In a multi-board system, the DP8513's REFIN and REFCLK inputs allow the graphics system's motherboard and slave boards to be synchronized from a single master clock source, such as the DP8514.

### Oscillating Factors

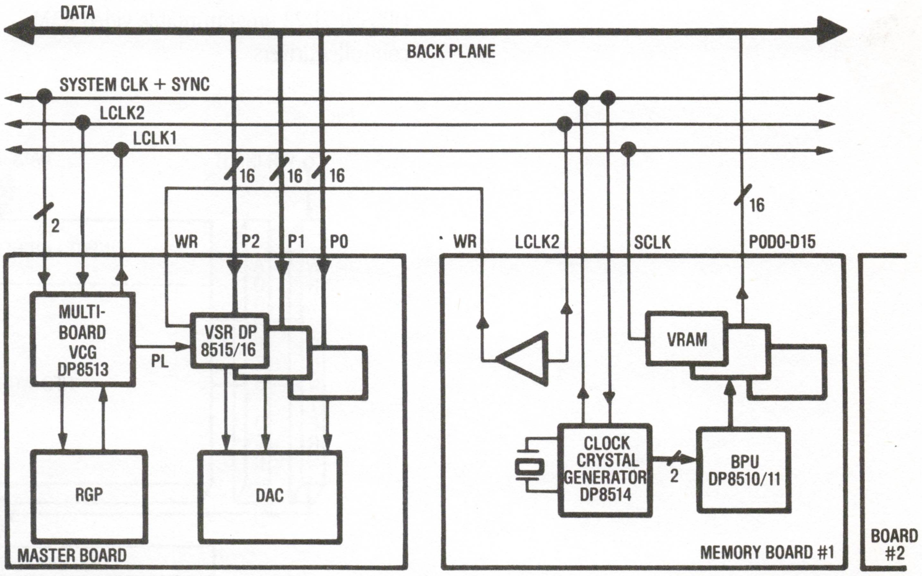
Although it is designed to work directly with the DP8513, the DP8514's features and flexibility allow it to be used in many other applications where conversion of the crystal oscillator signal into a device-level TTL-compatible signal is required.

The device consists of a crystal oscillator and a re-synchronizer/MOS clock generator, both of which may be used independently of each other. There are two TTL-compatible outputs from the crystal oscillator. The re-synchronizer has a clock input and a reference input (both TTL-compatible). The DP8514 can also be referenced to positive or negative ECL signals or a single 5-volt power supply.

### Common Core: Flexible Performance

The AGCS is the first partitioned, high-performance chip family designed to meet any required performance specifications. The family of chips, featuring various graphics functions, gives designers the performance they need to build a wide range of graphics products featuring a common hardware and software core.

MULTIBOARD GRAPHICS INTERFACE



# Video Shift Registers Speed Parallel-to-Serial Conversion

***A new version of the DP8515/16 video shift registers supports very high-resolution displays in graphics systems.***

The DP8515V-350 and DP8516V-350 are the latest members of National's Advanced Graphics Chip Set (AGCS). Featuring a parallel load rate of 30 MHz and a maximum shift rate of 350 MHz, the devices can also be used for very high-speed parallel-to-serial conversion in test equipment and fiber optic communications applications.

The two high-speed versions of the video shift register join the existing DP8515V and DP8516V, which feature a parallel load rate of 20 MHz and a maximum shift rate of 225 MHz.

### AGCS: Partitioned Graphics Functions

The original DP8515/16 video shift registers, introduced in mid-1986, were the first components of National's AGCS, which provides a new level of VLSI graphics performance for a wide range of systems designs.

The chips in the family, used as modular building blocks, feature "partitioned" graphics functions. When tied together in a systems design, they support a virtually unlimited number of color planes under the control of a single raster-graphics processor.

AGCS members include the DP8513/14 multi-board clock system, the DP8512 and DP8530 video clock generators, the DP8510/11 BITBLT processing units and the DP8520/21/22 programmable video RAM controller/drivers.

### Feature-Rich And Flexible

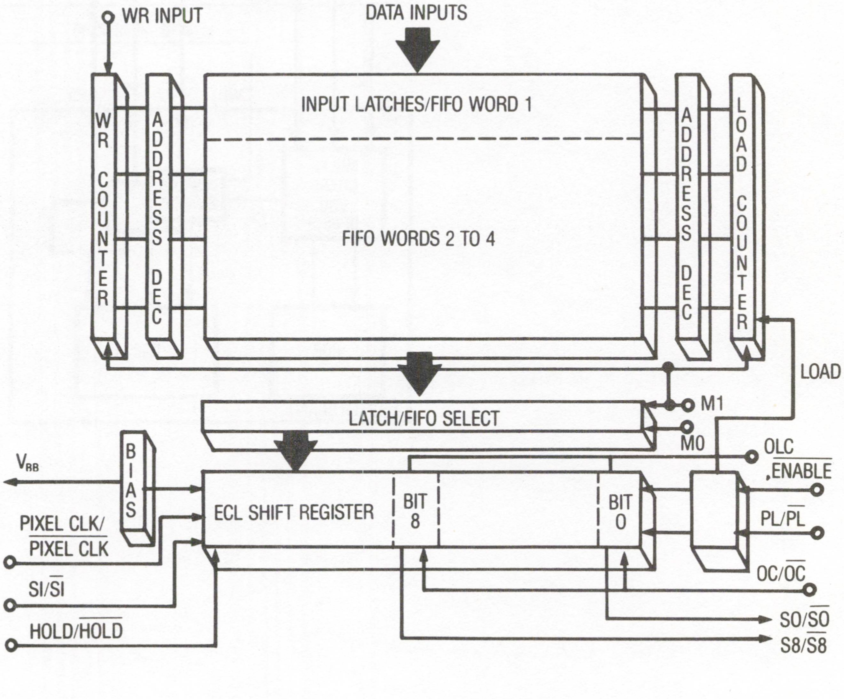
The new video shift registers are parallel-in, serial-out 16-bit units that can also act as two 8-bit shift registers through a tap at the eighth bit. They operate from a single +5-volt power supply, or plus and minus supplies, and feature four 16-bit words of FIFO, essential for high-speed multiple board systems.

Additional features include on-chip TTL-to-ECL translators and single-ended or differential ECL inputs and outputs, which add to the flexibility of the devices.

The devices have three input configurations: inputs set as transparent latches, inputs set as flip-flops (one-word FIFO mode) or inputs set up in a four-word FIFO mode. The four-word FIFO mode significantly eases system-timing constraints because it allows four write operations to occur before requiring a shift register load operation.

The DP8515V-350 and DP8516V-350 are fabricated with bipolar/CMOS process technology, offering users the advantages of both high speed and low power consumption.

The DP8515, available in a 44-pin PLCC, features 10K ECL-compatible outputs. The DP8516, offered in the same package, has 100K ECL-compatible outputs. Parallel data inputs on both units are TTL-compatible.


WR INPUT
DATA INPUTS
WR COUNTER
ADDRESS DEC
INPUT LATCHES/FIFO WORD 1
FIFO WORDS 2 TO 4
ADDRESS DEC
LOAD COUNTER
LOAD CLK
M1
LATCH/FIFO SELECT
M0
OLC
$\overline{ENABLE}$
$V_{RB}$
BIAS
ECL SHIFT REGISTER
BIT 8
BIT 0
PL/$\overline{PL}$
PIXEL CLK/$\overline{PIXEL CLK}$
OC/$\overline{OC}$
SI/$\overline{SI}$
HOLD/$\overline{HOLD}$
SO/$\overline{SO}$
S8/S8

# CMOS UARTS Go Portable

***National has upgraded its popular UART product line with CMOS device versions aimed at the portable PC market.***

The new NS16C450 and NS82C50A are functionally equivalent to their CMOS counterparts, the NS16450 and NS8250A, but consume only 10 milliamps of power in active mode. The new units function as serial data input/output interfaces in a microcomputer system. Their primary purpose is to provide full duplexed, bi-directional, asynchronous data communications between a CPU and a peripheral device, such as a printer, terminal or modem.

National is the leading supplier of UARTs for IBM PCs and compatibles, and its devices are installed in nearly all of those computers. The CMOS units are ideally suited for low-power applications, such as portable PCs.

## Programmable Baud Rate Generator

The new CMOS UARTs (Universal Asynchronous Receiver-Transmitters) contain a programmable Baud Rate Generator (BRG) that is capable of taking any clock input (DC to 3.1 MHz) and dividing it by any divisor. The baud rate (the rate at which serial data is transmitted or received) is equal to the output of the BRG, divided by the clock factor (16X).

The functional configuration of the UARTs, including the on-board BRG, is programmed by the system software through a TRI-STATE 8-bit directional data bus.

Also contained in the UARTs is a complete modem-control capability and a processor-interrupt system that may be software-tailored to minimize the computing required to handle the communications link.

Other features include full double-buffering; independently controlled transmit, receive, line status, and data-set interrupts; false start bit detection; and line break generation, detection and internal diagnostic capabilities.

Both the NS16C450 and NS82C50A are available now in 40-pin plastic and ceramic DIPs and 44-pin plastic leaded chip carriers (PLCCs).

# Application Specific ICs

For additional Application Specific IC products, see pages 19 and 231.

# Eight Analog Functions Added to National's ASIC Library

***Analog and digital functions can now be combined on a single chip, reducing board space in systems designs.***

National has placed eight analog functions into its standard cell library as a first step towards capturing a major share of the booming analog-digital standard cell IC market, which is expected to grow from $50 million in 1987 to over $2 billion by 1990. The analog cells are aimed at industrial controls, telecommunications, automotive applications and medical instrumentation.

## True Single-Chip Solutions

Some 227 digital cells are already available in the library. With the new analog cells, National now offers a mixed analog-digital capability for true single-chip solutions.

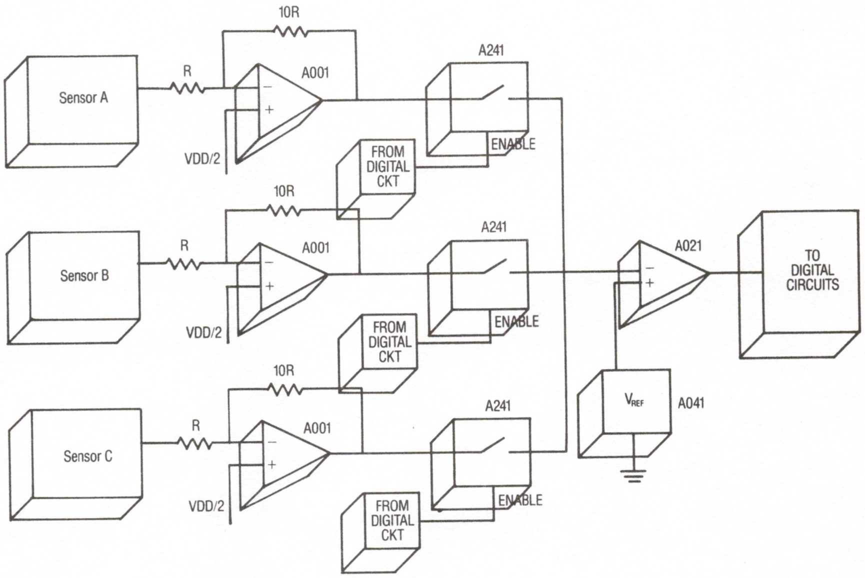
The eight analog functions include two comparators with different input common-mode ranges, three operational amplifiers with different gain-bandwidth products, a voltage reference, an analog switch and resistors.

The functions are based on National's advanced 2-micron $M^2$CMOS process. This process is widely used across National's many product lines and has been optimized to operate from 5-Volt supplies. Analog functions can amplify low-level signals from transducers and convert them to the voltage levels used by microprocessors.

## Smaller Is Better

With combined analog and digital cells on the same chip, fewer components will be needed in systems designs, resulting in reduced board space, smaller power supplies and increased reliability. These attributes are essential to battery-powered portable systems. Additionally, the resulting smaller designs will allow more features to be packed into customer systems.

"These analog building blocks add a new dimension to our fast-growing library of digital cells," says Mike Bereziuk, director of marketing for National's ASIC Division. "They provide the designer with the capability of integrating more of a total system onto a single IC, thus gaining all the cost and performance advantages of a complete ASIC solution."



**OPERATIONAL AMPLIFIERS**

| MACRO | GAIN BANDWIDTH | REMARKS |
|---|---|---|
| A001 | 0.75 MHz | VINCM: 0.3V |
| A002 | 1.5 MHz | TO VDD−1.5V |
| A003 | .3 MHz | |

**RESISTORS**

| | |
|---|---|
| A331 TO A335 | 100Ω, 500Ω, 1KΩ, 2KΩ, & 20KΩ ±1% MATCH |
| A361 TO A365 | 1KΩ, 3KΩ, 5KΩ, 6KΩ, 100KΩ ±5% MATCH |

**COMPARATORS**

| MACRO | RESPONSE TIME | REMARKS |
|---|---|---|
| A021 | 250 NS WITH 10MV OVERDRIVE | VINCM: 1.5V TO VDD−0.5V |
| A022 | 180 NS WITH 10MV OVERDRIVE | VINCM: 0.3V TO VDD−1.5V |

**VOLTAGE REFERENCE**

| | BAND GAP REFERENCE |
|---|---|
| A041 | 2.5 VOLTS |

**ANALOG SWITCH**

| | |
|---|---|
| A241 | ON RESISTANCE = 100 OHMS<br>$T_{ON} = 30_{NS}$, $T_{OFF} = 30_{NS}$ |

# FACT/FAST

For additional Logic products, see pages 89 and 273.

# FAST™ Family Expansion Continues

***The introduction of 18 new devices to the FAST (Fairchild Advanced Schottky-TTL) family of bipolar digital logic circuits ups the total number of available FAST products to 130.***

The new device types encompass a wide variety of functions, including gates, buffers, latches, line drivers and flip-flops. Each of the new products operates over the standard commercial temperature range of 0°C to +70°C, with supply voltage tolerance ($V_{cc}$) guaranteed at 5V ±10%.

### A Potpourri Of Products

The 74F841/843/845 are 10-bit buffer/line drivers that feature broadside pinouts. They provide high-performance bus-interface buffering for wide data/address paths or buses carrying parity for microprocessor applications.

The 74F841/843/845 are 10-, 9- and 8-bit transparent latches, respectively. They are designed to eliminate the extra packages required to buffer existing latches and provide extra data width for wider address/data paths.

The 74F821/823/825 are 10-, 9- and 8-bit D-type flip-flops featuring broadside pinouts. The 74F366/368, meanwhile, are high-speed bus-oriented hex inverter buffers with 3-state outputs capable of sinking 64 mA.

The 74F657 is an octal bidirectional transceiver with an 8-bit parity generator/checker and 3-state outputs for bus-oriented applications. It combines the functions of the 74F245 and 74F280A in one package. The device also features input diodes for termination effects, and its outputs are capable of sinking 64 mA.

| DEVICE | FUNCTION |
|---|---|
| 74F27 | Triple 2-Input NOR Gate |
| 74F30 | 8-Input NAND GATE |
| 74F37 | Quad 2-Input NAND Buffer |
| 74F38 | Quad 2-Input NAND Buffer (OC) |
| 74F40 | Dual 4-Input NAND Buffer |
| 74F51 | AND/OR Invert Gate |
| 74F125 | Quad Buffer |
| 74F366 | Hex Inverter/Buffer |
| 74F368 | Hex Inverter/Buffer |
| 74F657 | Octal Bidirectional Transceiver With Parity |
| 74F821 | 10-Bit D Flip-Flop |
| 74F823 | 9-Bit D Flip-Flop |
| 74F825 | 8-Bit D Flip-Flop |
| 74F827 | 10-Bit Buffer/Line Driver |
| 74F828 | 10-Bit Buffer/Line Driver |
| 74F841 | 10-Bit Transparent Latch |
| 74F843 | 9-Bit Transparent Latch |
| 74F845 | 8-Bit Transparent Latch |

# National Introduces 23 FACT™ Standard Military Drawings

| Device | Pins | Designation | Description |
|---|---|---|---|
| 54AC00 | 14 | 5962-97549 | Quad 2-Input NAND Gate |
| 54AC02 | 14 | 5962-87612 | Quad 2-Input NOR Gate |
| 54AC04 | 14 | 5962-87609 | Hex Inverter |
| 54AC08 | 14 | 5962-87615 | Quad 2-Input NAND Gate |
| 54AC10 | 14 | 5962-87610 | Triple 3-Input NAND Gate |
| 54AC11 | 14 | 5962-87611 | Triple 3-Input AND Gate |
| 54AC14 | 14 | 5962-87624 | Hex Inverter Schmitt Trigger |
| 54AC20 | 14 | 5962-87613 | Dual 4-Input NAND Gate |
| 54AC32 | 14 | 5962-87614 | Quad 2-Input NOR Gate |
| 54AC138 | 16 | 5962-87622 | 1-of-8 Decoder |
| 54AC151 | 16 | 5962-87691 | 8-Input Multiplexer |
| 54AC153 | 16 | 5962-87625 | Dual 4-Input Multiplexer |
| 54AC174 | 16 | 5962-87626 | Hex D Flip-Flop with Reset |
| 54AC240 | 20 | 5962-87550 | Octal Buffer/Line Driver |
| 54AC241 | 20 | 5962-87551 | Octal Buffer/Line Driver |
| 54AC244 | 20 | 5962-87552 | Octal buffer/Line Driver |
| 54AC251 | 16 | 5962-87692 | 8-Input Multiplexer/3-State |
| 54AC253 | 16 | 5962-87693 | Dual 4-Input Multiplexer/3-State |
| 54AC373 | 20 | 5962-87555 | Octal Latch |
| 54ACT138 | 16 | 5962-87554 | 1-of-8 Decoder |
| 54ACT139 | 16 | 5962-87553 | 1-of-4 Decoder |
| 54ACT245 | 20 | 5962-87663 | Octal Transceiver |

**Contact your local National Sales Office for more information.**

# FAST™ And FACT™ Receive Military Qualification

***Twenty different FAST and FACT logic products from Fairchild have been qualified to MIL-STD-883C, opening the way for their use in applications over the full military temperature range.***

Sixteen FACT (Fairchild Advanced CMOS Technology) devices and four FAST (Fairchild Advanced Schottky-TTL) products have been qualified to MIL-STD-883C.

With these developments, 77 FAST devices have received MIL-STD-883C qualification, 46 are qualified under JAN B and 38 have received JAN S QPL II certification. FACT, meanwhile, now offers 63 devices characterized over the military temperature range; 43 of those products are 883C-qualified and a number are available to Standard Military Drawings (SMDs).

### FAST On Target

The four FAST devices recently 883C-qualified include the following:

*54F365 Hex Buffer/Line Driver w/3-State Outputs*–The 54F365 FAST device type offers tPLH at 14.0 ns maximum; tPHL is 9.0 ns maximum.

*54F407 Data Access Register*–This device performs memory address arithmetic for RAM-resident stack applications. Compatible with all TTL families, the 54F407 is expandable in 4-bit increments and can operate at a 30 MHz microinstruction rate on a 16-bit word.

*54F827/828 Buffer/Line Drivers w/3-State Outputs*–These two FAST products provide high-performance bus interface buffering for wide data/address paths or buses carrying parity. They are designed for use as memory address drivers, clock drivers and bus-oriented transmitter receivers.

| **DEVICE** | **FUNCTION** |
|---|---|
| 54AC74 | Dual D-Type Positive Edge-Triggered Flip-Flop |
| 54AC109 | Dual JK Positive Edge-Triggered Flip-Flop |
| 54AC163 | Synchronous Presettable Binary Counter |
| 54AC245 | Octal Bidirectional Transceiver |
| 54AC273 | Octal D Flip-Flop |
| 54AC540 | Octal Buffer/Line Driver w/3-State Outputs |
| 54ACT00 | Quad 2-Input NAND Gate |
| 54ACT74 | Dual D-Type Positive Edge-Triggered Flip-Flop |
| 54ACT109 | Dual JK Positive Edge-Triggered Flip-Flop |
| 54ACT153 | Dual 4-Input Multiplexer |
| 54ACT157 | Quad 2-Input Multiplexer |
| 54ACT240 | Octal Buffer/Line Driver w/3-State Outputs |
| 54ACT244 | Octal Buffer/Line Driver w/3-State Outputs |
| 54ACT245 | Octal Bidirectional Transceiver w/3-State Inputs/Outputs |
| 54ACT253 | Dual 4-Input Multiplexer w/3-State Outputs |
| 54ACT257 | Quad 2-Input Multiplexer |
| 54F365 | Hex Buffer/Line Driver |
| 54F407 | Data Access Register |
| 54F827 | Buffer/Line Driver |
| 54F828 | Buffer/Line Driver |

# The FACT™ Family Grows: A Dozen New Devices Added

***Fairchild's FACT (Fairchild Advanced CMOS Technology) family of advanced CMOS digital logic circuits has grown to encompass 73 devices with the addition of twelve new products in the 74AC/ACT series.***

Like all members of the FACT family, the new devices feature power consumption levels as low as 0.1 mW per gate at a 1 MHz clock frequency. Each of them has identical output stages and is guaranteed to source or sink 24 mA, while featuring internal gate delays of 1 nanosecond and worst-case propagation delays of 5 ns.

The 74AC/ACT series is guaranteed to drive 50-ohm transmission lines. High DC and dynamic output drive currents make the family ideal for driving low-impedance transmission lines and highly capacitive nodes.

### Freedom From Latch-Up

The FACT family is manufactured with a 1.2-micron silicon-gate CMOS process that makes high switching speeds possible while effectively eliminating the traditional latch-up phenomenon associated with earlier CMOS families.

The new AC devices all have CMOS-compatible inputs, while the ACT versions feature TTL-level inputs. Since they feature TTL-type input thresholds, the ACT versions can be used as direct replacements for standard and advanced low-power Schottky devices.

Each of the products is available over the −40°C to +85°C commercial temperature range. The 'AC00, 'AC74, 'AC163, 'ACT109, 'ACT299, 'ACT563 and 'ACT564 are also available over the military temperature range, −55°C to +125°C.

| DEVICE TYPE | FUNCTION |
|---|---|
| 74AC00 | Quad 2-Input NAND Gate |
| 74AC74 | Dual D-Type Positive Edge-Triggered Flip-Flop |
| 74AC163 | 4-Bit Binary Counter |
| 74AC191 | 4-Bit Up/Down Binary Counter |
| 74AC299 | 8-Input Universal Shift/Storage Register |
| 74ACT109 | Dual JK Positive Edge-Triggered Flip-Flop |
| 74ACT161 | 4-Bit Binary Counter |
| 74ACT163 | 4-Bit Binary Counter |
| 74ACT299 | 8-Input Universal Shift/Storage Register |
| 74ACT534 | Octal D-Type Flip-Flop |
| 74ACT563 | Octal D Latch |
| 74ACT564 | Octal D Flip-Flop |

# FACT™ Family Expansion Continues

***Five new commercial devices and four MIL-STD-883C-qualified devices have been added to the FACT family of standard logic products.***

Counting the new additions, 76 FACT devices are now available with approval over the commercial temperature range, and 44 device types have met MIL-STD-883C qualification.

**Commercial Qualifications**

The FACT 74AC708 is an expandable FIFO memory organized as 64 words by 9 bits. An 85-MHz shift-in and 60-MHz shift-out data rate make it ideal for high-speed applications. This device is the fastest 64 × 9 CMOS-level FIFO available on the market.

The FACT 74AC161 is a high-speed synchronous binary counter. It is synchronously presettable for use in programmable dividers, with two types of count-enable inputs and a terminal-count output that provides flexibility in forming synchronous multistage counters.

The 74AC257 uses a common data-select input to present selected data from its four outputs in noninverted form. The outputs may be switched to a high-impedance state by placing a logic HIGH on the common output-enable input, allowing direct interface with bus-oriented systems.

The 74ACT323 is an 8-bit universal shift/storage register with 3-state outputs. Parallel load inputs and flip-flop outputs are multiplexed to minimize pin count. Four operation modes are possible: hold (store), shift left, shift right and parallel load.

The 74ACT399 is the logical equivalent of a quad 2-input multiplexer feeding into four edge-triggered flip-flops. A common select input determines which of the two 4-bit words is accepted. The selected data enter the flip-flop on the rising edge of the clock.

**MIL-STD-883C Qualifications**

The reversible 54AC191 binary counter features synchronous counting and asynchronous presetting. The preset feature allows the device to be used in programmable dividers, while the count-enable input, the terminal-count output and the ripple clock output make possible a variety of methods of implementing multistage counters.

The 54ACT151 high-speed 8-input digital multiplexer provides the ability to select one line of data from up to eight sources. It can be used to generate any logic function of four variables; both true and complementary outputs are provided.

The high-speed quad 2-input 54ACT158 multiplexer selects four bits of data from two sources using the common select and enable inputs. The four buffered outputs present the selected data in the inverted form. This device may also be used as a function generator.

The 54ACT299 is an 8-bit universal shift/storage register with 3-state outputs. Four modes of operation are possible: hold (store), shift left, shift right and load data. The parallel load inputs and flip-flop outputs are multiplexed to reduce the total number of package pins; additional outputs are provided for easy serial cascading.

**Commercial FACT Devices**

| | |
|---|---|
| 74AC708 | 64 × 9 FIFO Memory |
| 74AC161 | Synchronous Presettable Binary Counter |
| 74AC257 | Quad 2-Input Multiplexer/3-State |
| 74ACT323 | 8-Bit Universal Shift/Storage Register |
| 74ACT399 | Quad 2-Port Register |

**MIL-STD-883C Qualifications**

| | |
|---|---|
| 54AC191 | Up/Down Binary Counter |
| 54ACT151 | 1-of-8 Decoder/Demultiplexer |
| 54ACT158 | Quad 2-Input Multiplexer |
| 54ACT299 | 8-Input Universal Shift/Storage Register |

# New FACT™ LSI 16 x 16 Multipliers Introduced

***Fairchild's 74ACT1010 parallel multiplier/accumulator and 74ACT1016 multiplier are the first LSI circuits in the FACT digital logic family of products.***

The new LSI devices are designed for use in applications in video processors, radar and digital signal processing, array and Fast Fourier Transform (FFT) processors, and computer hardware accelerators. The 74ACT1010 and 74ACT1016 are available in industry-standard pinouts, are TTL-compatible and offer a commercial temperature range of −40°C to +85°C.

The 74ACT1010 features selectable accumulation, subtraction, rounding and preloading with a 35-bit result. It is offered in two high-speed versions: 55 nanosecond and 65 ns maximum multiply/accumulate times. The clock multiply time of the 74ACT1016, meanwhile, is 70 ns maximum.

**Low Power Consumption**

The low power consumption of the 74ACT1010–typically less than 250 mW–is less than 1/15 the power of compatible bipolar designs and 1/7 the power of NMOS designs. Both devices feature power consumption levels as low as 0.1 mW per gate at 1 MHz clock frequency, internal gate delays of 1 ns and typical output register propagation delays of just 15 ns.

The 74ACT1010 and 74ACT1016 have identical output stages and are guaranteed to source or sink 8 mA. TTL-type input thresholds allow these FACT products to replace standard bipolar input-level devices. They are capable of driving 100-ohm transmission lines, thus lowering overall system costs by reducing the requirement of putting line drivers on all 35 outputs.

# FAST™ Adds Three Device Types To JAN B QPL

The three device types are the 54F181 4-Bit Arithmetic Logic Unit and the 54F563/573 Octal D-Type Latches with 3-State Outputs. The 54F181 ALU performs all of the possible 16 logic operations on two variables and a variety of arithmetic operations. The 54F563 and 54F573 are high-speed octal latches with buffered common Latch-Enable and buffered common Output-Enable inputs.

In addition to the JAN B device types, JAN Class S QPL II reliability certification has been granted for the FAST 54F373 Octal Transparent Latch and the 54F521 8-Bit Identity Comparator. JAN S certification has also been granted for the Low-Power Schottky 54LS244 Octal Buffer/Line Driver and the 54LS273 8-Bit Register.

The JAN B device types are available in CDIP, flatpak and leadless chip carrier (LCC) packaging.

| **Device Type** | **Function** |
|---|---|
| 54F181 | 4-Bit Arithmetic Logic Uni |
| 54F563 | Octal D-Type Latch |
| 54F573 | Octal D-Type Latch |

# Linear

For additional Linear products, see pages 67 and 247.

## Smart High-Side Driver Safely Switches Inductive Loads

### *The LM1951 combines complete protection with fault reporting for switching grounded loads.*

The lack of a reliable switch to handle inductive loads has been a long-standing problem for systems designers; to design for all possible contingencies using discrete power devices consumes too much board space and is costly. In addition, protection from load faults (short or open) and transients must be part of the design.

Traditionally, circuit designers have used "low-side" drivers which switch between a "hot" load and ground. They provide a simple interface between 5V logic systems and discrete power devices. In many applications, however, hot loads present unacceptable safety problems.

**First Of The Smart Switches**

National's new monolithic LM1951 High-Side Driver offers a unique solution to this design dilemma. This 1-Amp switch is rated for operation to 26V and will withstand up to ±85V transients. Also on-board are over-voltage and thermal shutdown features, as well as complete short-circuit protection.

The LM1951 not only protects itself from a load fault but also alerts the system that the fault condition has occurred. The driver features a diagnostic flag which goes "low" and tells the system controller to take corrective action in the event of a load short, open or excessive die temperature.

The LM1951 is well-suited for applications where it is connected to a battery. It offers an extremely low typical quiescent current drain of 0.1 uA (10 uA max.) at room temperature and guarantees less than 100 uA maximum over the full junction operating temperature range (−40°C to +150°C).

**Reverse Voltage Protection**

Since the LM1951 is built with National's Deep Base bipolar process, reverse voltages on the output will not harm the device. Other high-side switches contain diodes which do not allow the output to go below ground.

The LM1951 comes in a 5-lead TO-220 package. Heat sinking is usually not necessary, since the drop across the device is guaranteed to be less than 1V at full-rated load current.

All input voltage thresholds are TTL-, CMOS- and LSTTL-compatible. They all feature 200-mV typical hysteresis for greater noise immunity.

## New Reference Guarantees Wide Temperature Range

### *The LM169 is the first precision monolithic voltage reference to guarantee a temperature coefficient of 3 PPM/°C across a full −55°C to +125°C range.*

The LM169 often surpasses its guarantee of 3PPM/°C, relying on special temperature compensation techniques to achieve a low *typical* temperature coefficient (Tempco) of 1 PPM/°C. This contrasts with previous methods, which incorporated a heater on the die.

This advance eliminates the need for additional power to run the heater. It also eliminates a prolonged warm-up time when the reference is first powered. Most important, the Tempco performance is not degraded when the temperature exceeds 85°C, the die temperature at which heated references regulate.

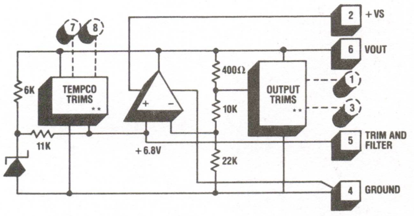
**Guaranteed Accuracy**

In Line with its superior performance, the LM169 typically achieves a V-out accuracy as low as 1 mV (0.01%) and guarantees an initial accuracy of 5mV (0.05%). The device also boasts a load regulation of 8PPM/mA and line regulation of 1PPM/V, the best in the industry on both specifications.

**Potentiometer Trimming**

The LM169 can also be trimmed with the addition of a potentiometer for any application demanding maximum accuracy. Trimming V-out does not adversely affect the temperature coefficient.

In applications like test and measurement equipment, the LM169 can be filtered with a small capacitor between a trim pin and ground to dramatically decrease output noise.



**PATENT PENDING

# Low-Cost Quad Op Amp Offers High-Drive Capabilities

***National's new LM837 quad op amp features a new type of output stage that allows it to outperform dual devices in signal conditioning circuits.***

Although National's new LM837 quad op amp was primarily designed for audio circuitry performance, it is gaining widespread acceptance in many instrumentation, telecommunications, and other signal processing applications.

The LM837 features a new type of output stage which drives a 600 ohm load, making it ideal for a wide variety of amplification and signal conditioning circuits. Moreover, its low distortion of 0.0015% and low input noise of 0.5 uV are not affected by such loads.

**Half The Board Space Of Duals**

With a bandwidth of 15 MHz and a slew rate greater than 8 V/microsecond, the high-performance LM837 offers better price/performance than any competitive dual device on the market. It takes up half the board space of comparable dual performance, equals the reliability of these devices and lowers design costs.

Another inviting application for this low noise quad op amp is in active filter circuits, where noise is compounded with each successive cascaded stage. Performance in high-Q filter circuits is aided by the high (15MHz) gain bandwidth. In addition, the ±40mA output drive capability of the LM837 enhances its ability to drive low-impedance feedback networks.

**Low Noise And Distortion**

Low noise and low distortion levels give the LM837 quad op amp a design advantage in signal generators, where producing a clean signal is paramount. Its unity gain stability functions as another important feature in this respect.

The high current drive capability provides fast charging of holding capacitors for virtually any applications employing sample/hold, peak detection, AGC or data conversion techniques.

**Easy System Upgrades**

Upgrading an existing system requires little or no changes since the LM837 pin-out is compatible with most other standard quad op amps. By replacing many duals or lesser quad op amps, a significant improvement in the signal-to-noise ratio, signal handling capability and bandwidth can be expected.

## Wideband Video Buffer Targeted For High-Speed Applications

***The fast unity-gain LH4002 video driver is designed to offer OEMs high-current drive capability.***

For high-speed video applications, nothing offers more high-current drive than National's new LH4002 Wideband Video Buffer. Designed to drive video signals from DC to 200 MHz with a guaranteed 100 MHz bandwidth, this high-speed voltage follower operates on just ± 5V.

The LH4002 video amplifier fills a wide range of high-speed applications from video distribution to impedance transformations and load isolation with its ability to directly drive 50- and 75-ohm lines at slew rates in excess of 100 V/us.

### Increased Output Current

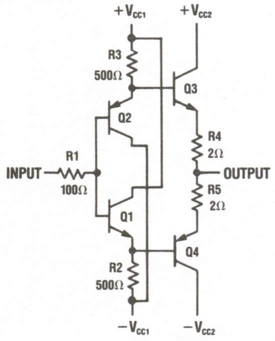
As a current booster in an op amp loop, the device will increase the output current of existing op amps by as much as threefold.

The LH4002 is also well-suited for raster graphic applications, with a phase linearity of 2 degrees and distortion less than 0.1 percent.

Since the frequency response is flat over the 100 MHz bandwidth, the pulse response overshoot is minimized. This makes the LH4002 an excellent cable driver for high-speed digital and analog signals.

### Pin-Compatibility

This wideband video buffer is pin-compatible with the industry-standard LH0002. The LH4002 is available in a 10-pin plastic DIP, using a unique lead-frame construction which offers superior heat dissipation over a metal TO-5 package. The device is also available as a military version in the 8-pin TO-5 package.



## SLIC Gets Smaller

***National's new TP3200 bipolar IC uses magnetic compensation to reduce the size and cost of SLIC transformers.***

Although Subscriber-Line Interface Circuit (SLIC) technology is evolving at a steady pace, most monolithic approaches have suffered from being too expensive or bulky. They also have been unable to handle high-ranging voltages and other performance demands of Central Office applications and trunk lines.

Ultimately, it is expected the semiconductor industry will produce a low-cost solution which offers high performance without requiring a transformer.

### No Magnetic Saturation

For now, National's new magnetic compensated SLIC circuits are offering the telecommunications world an attractive interim answer in terms of price, size and performance.

Through a series of design innovations, the new magnetic-compensated TP3200 SLIC retains all the advantages of transformer performance without resorting to larger, more expensive transformers.

Magnetic compensation reduces the DC flux build-up in the SLIC transformer and thus allows the use of a small, accurately wound core with no air gaps. This small ferrite core transformer can provide the large inductance needed without creating side effects.

### A Longitudinal Balancing Act

The SLIC circuit also provides an excellent longitudinal balance of 60 dB min. even in the face of an induced current from a nearby power line. Special Si-chrome thin film resistors help make this possible.

The reliability of the ring tripping circuitry is not a problem with this monolithic SLIC. In fact, a special latch pin is dedicated for the ringing relay.

By carefully timing the ringing synch signals, the relay contacts are not subject to voltage arcs and subsequent rapid wear. The two remaining latch pins can then be used for circuit testing or battery reversal.

## Op Amps Offer High Current Output

***The LH4104 and LH4105 wideband op amps offer 500 ns settling times, optimizing them for a wide range of data acquisition and test & measurement applications.***

The fast settling times of the LH4104 and LH4105 (to 0.01% accuracy) make them ideal precision cable drivers, video buffers, waveform generators and DAC output amplifiers.

### No Current Boosters Required

A high current output of ± 100 mA allows the op amps to drive 50 and 75 ohm loads, eliminating the need for added current boosters.

The LH4104 offers a guaranteed maximum input offset voltage of 5 mV, compared with a guaranteed maximum of 500 uV for the LH4105. Both of these unity-gain stable op amps contain internal supply bypass capacitors rather than requiring external compensation.

Key parameters for pulse amplifiers and high-speed video applications include a 40V/us slew rate and a full 18 MHz gain bandwidth.

Both operational amplifiers are available in 12-pin metal TO-8 packages. Full military-processed versions of the LH4104 and LH4105 are also available.

## Closed-Loop Buffers Offer High-Gain Accuracy

***National's LH4003 and LH4006 Precision RF Buffers exhibit a fast slew rate and easy design features.***

Traditional open-loop buffers have typically suffered from poor gain accuracy. The new LH4003 Precision RF Closed-Loop Buffer corrects the problem with a high-gain accuracy of 0.95 into a 50-ohm load. The device also features a fast slew rate of 1000 V/us, along with unity-gain stability.

Intended for applications in video buffering, driving long cables and conditioning flash converter input signals, the LH4003 substantially eases the designer's task. The buffer has internal short-circuit protection and internal power-supply bypass capacitors (0.01 uF) to make it relatively immune to circuit-board layout problems.

### Guaranteed Small-Signal Bandwidth

The LH4003 has a guaranteed 200-MHz small-signal bandwidth. A sister closed-loop buffer, the LH4006, comes with all the same performance features, plus a guaranteed bandwidth of 300 MHz.

The two buffers operate from ±6-Volt supplies. In their quiescent state, they typically draw 55 mA. Both buffers are available in a 24-pin ceramic DIP with full commercial and military operating temperature ranges.

## Battery-Powered Comparator Sounds Alarm

***National's LM1801 Low-Power Comparator is a complete, monolithic solution to a wide variety of sensing, monitoring and alarming applications.***

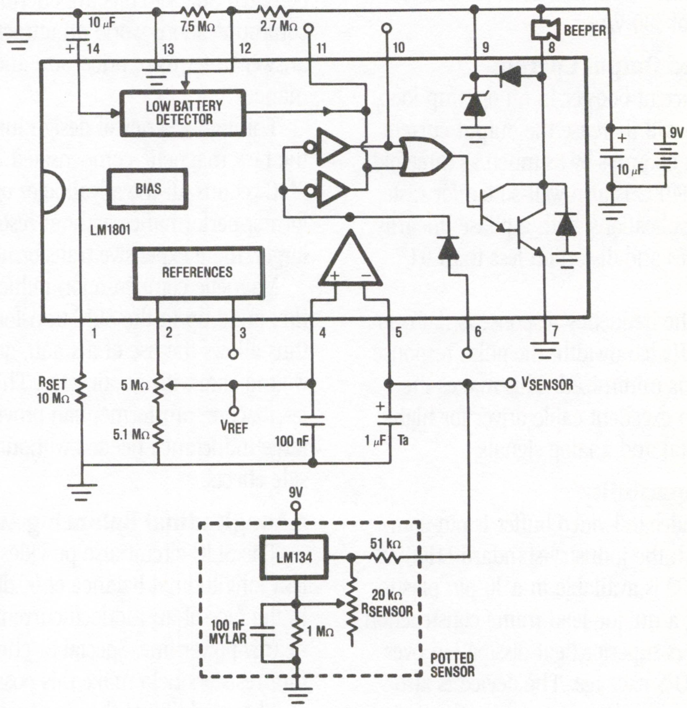
Powered by a single 9-volt battery, the LM1801 comparator will operate in a standby mode up to one year. The device will also run off any available power supply from 8 to 14 volts, using an on-board 14.5 zener clamp for supply regulation in line applications.

The LM1801 is packed with useful features. Two on-chip references serve as bias points for other circuit functions. A low-battery detector on-board will warn of circuit power failure. The device's 500mA output stage is sufficient to drive a beeper or buzzer in intrusion alarm systems.

### Low Power Appetite

The LM1801 only consumes 6μA in a quiescent state, yet the comparator can source or sink a full 0.5A in a switched state.

For maximum utility, a parallel output enables up to nine LM1801 comparators to be tied to one alarm. In addition, a feedback pin provides a hysteresis feature to help prevent false alarms. A latching function is also available through the feedback pin to prevent the comparator from being accidentally turned off.



# Memory

For additional Memory products, see pages 113 and 311.

## National Enters OTP EPROM Market

***National's new NMC27C64N CMOS One-Time Programmable (OTP) 64K-bit EPROM matches the reliability levels of ceramic parts while offering users considerable cost savings.***

The device is the first CMOS EPROM to be offered by National in a molded plastic package. Unlike ceramic parts, it does not have the transparent lid used to expose the EPROM to ultraviolet light, thus optimizing it for high-voltage production applications. These include automotive engine control, anti-skid braking systems, computers, avionics systems and industrial control equipment.

**Plastic Packaging: More to Come**

The NMC27C64N 64-K bit CMOS EPROM is designed to operate with a single +5-volt power supply. It is available now in a 28-pin dual-in-line package (DIP) and will soon be offered in a 32-pin plastic leaded chip carrier (PLCC).

Plans are underway to offer National's entire comprehensive line of ultraviolet-erasable CMOS EPROMS in the new packages. The family includes 16K-, 32K-, 64K-, 128K-, 256K-, 512K-, and 1,024K-bit devices.

**No Erasure Problems**

OTP EPROMs are a natural choice during the manufacturing process because they offer users cost savings over ceramic EPROMs and are not susceptible to erasure.

Customers who use more than a few hundred CMOS EPROMs a year will benefit from the availability of the OTP unit. Ceramic windowed EPROMs would still be used during the development process until final, debugged programming code is completed.

## New EEPROMs Packaged In Small 18-Pin DIPS

***Three new CMOS EEPROMs feature multiplexed data and address lines that allow the devices to be packaged in small 18-pin dual in-line packages (DIPs), saving designers board space.***

The NMC98C10, NMC98C20 and NMC98C40 1K, 2K and 4K EEPROMs are 5-volt programmable, non-volatile, parallel-access memories built with a CMOS floating-gate process. The devices meet the JEDEC pin-out for static RAMs with multiplexed address/data, allowing for simplified designs and systems flexibility. They can be directly interfaced with many industry-standard 8-bit and 16-bit microprocessors and microcontrollers.

The units are compatible with National's Series 32000 16/32-bit and NSC800 8-bit microprocessors and the HPC 16-bit microcontroller family.

**Simplified Write Cycle**

The write cycle of the devices is simplified by a self-timed erase-before-write circuit on the chip. The end of the write cycle can be determined by polling the data pins or allowing a minimum time between a write command and a subsequent command.

In order to prevent undesirable modification of the memory contents during system power-up or power-down, a lock-out circuit ignores write commands when $V_{CC}$ is below prescribed levels.

The three EEPROMs also feature very low power dissipation and a minimum of 10,000 erase/write cycles.

**Easy Storage and Retrieval**

The NMC98C10/20/40 EEPROMs are targeted at the telecommunications, automotive, consumer, computer and industrial control industries. The family allows easy storage and retrieval of configuration parameters, security/password data, and PBS switch data, as well as wear parameters for self-adjusting machinery and retrieval of important data during power failure.

To assure availability, National has signed a non-exclusive, second-source agreement with Sierra Semiconductor covering the devices.

# Microcontrollers

For additional Microcontroller products, see page 125.

# National Introduces World's Fastest 16-Bit CMOS Microcontroller

***The HPC 16083V30 runs at a clock rate of 30 MHz, optimizing it for many new speed-critical applications previously beyond the reach of microcontrollers.***

The HPC16083V30's speed allows system designers to implement more features on-board with software rather than hardware, reducing overall system size and cutting costs.

Featuring an extremely fast instruction-cycle time of 134 nanoseconds, the device is more than 100 ns quicker than the 17 MHz version of the part, introduced last year. Its ability to gather and process information swiftly makes it ideally suited for near-future applications, such as microwave landing systems for airliners. It can also be used in automotive adaptive braking systems, laser and high-end dot matrix printers, and robotic control systems, where very high band-width-processing is required.

### Software Benchmarks Tell the Tale

In software benchmark tests with other leading microcontrollers, the HPC16083V30 was clearly the fastest device. The benchmarks were based on 11 software operations, including a 512-byte block move, bubble sort, 16 by 16 multiply, 12 by 12 BCD multiply, I/O manipulation, 4-digit BCD add and 16-bit binary add.

Rated at 30 MHz, the HPC16083V30 features six working registers, a micro-instruction ROM, clock generator, four 16-bit timer/counters, control logic, WATCHDOG and reset circuitry and National's MICROWIRE/PLUS™ serial I/O bus interface.

Direct internal/external addressing through 64K-bytes of memory space allows interfacing to external memory, peripherals or other processors.

### Newest Member of HPC Family

The HPC16083V30 is the latest member of National's 16-bit High Performance microController (HPC) family, which features a common-core architecture and very fast operating speeds. Based on the company's advanced CMOS technology, the family combines high speed with a modular design, allowing systems designers to select the microcontroller that best fits their application.

Each member of the HPC family has the same high-performance processor "core." Different selection of on-board memory, peripherals and I/O functions are built around the core to form specific products.

The HPC family is backed by a wide range of low-cost development tools, including high-level language compilers and assemblers for a variety of host computers.

# HPC™ Software Support Package Aids Program Development

***A new support package for National's family of 16-bit CMOS HPC microcontrollers features a relocatable assembler that improves the efficiency of software development.***

The HPC Assembler/Linker/Librarian produces relocatable object modules from the HPC macro assembly-language instructions, which are linked and located to absolute memory locations. The absolute object module can be downloaded to the HPC MOLE™ (Microcontroller On-Line Emulator) development system for debugging.

The relocation procedure allows independent groups of programmers to work on separate sections of an assembly-language program at the same time. The modules can then be linked together to form a complete software program.

### C Compiler: Part Of The Package

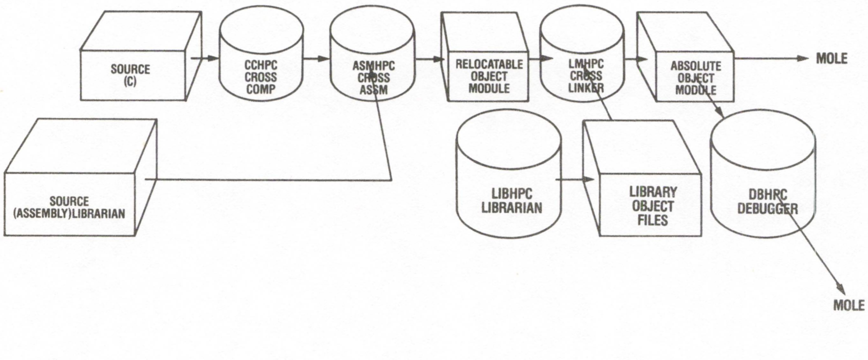
Along with the HPC Assembler/Linker/Librarian, an HPC C Compiler also comprises the software support package, which is offered on a variety of host computer systems. Versions are available for IBM PC XTs and ATs running PC DOS, and VAX™ minicomputers running the VMS and UNIX® operating systems.

The C Compiler generates assembly source code and may optionally pass symbolic information through the assembler and linker to the absolute object module. A source debugger then uses this information for C and assembly-language debugging on the host computer, in conjunction with the MOLE system.

The HPC C Compiler is a complete implementation of ANSI Draft Standard C, released in February 1986. It includes some variations that are required for microcontrollers and can be purchased separately from the HPC Software Support Package. An HPC C Compiler evaluation module is also offered at no charge which is identical to the full version but is limited to about 1,000 lines (3 kilobytes) of assembled code.

### HPC Training Schools

As part of its HPC support program, National offers classes on all of its HPC microcontrollers and development tools. The classes include extensive coverage of the HPC Assembler/Linker Librarian and HPC C Compiler, and are taught by factory application engineers who have design experience in many application areas.



# Low-Cost Design Kits For HPC Microcontrollers

***Two low-cost HPC (High Performance microController) design kits available from National allow designers to easily integrate the world's fastest 16-bit CMOS microcontroller into system designs.***

The kits, an evaluation package and a development package, are actually 16-bit microcontroller development systems used for program development and real-time emulation. An on-board HPC micro-controller executes monitor firmware and also acts as the target processor.

When used as a target processor, all HPC features, including up to 64K bytes of addressable memory, are available for use in the application.

### Kit Contents

Both kits contain all of the components, manuals and software needed to design an HPC system. The only additional equipment required is an IBM PC or compatible system, a +5-volt power supply and RS232 cables.

The kits include an HPC evaluation board, an In-System Emulator (ISE) cable, development board communications software, a C Compiler software evaluation module, an HPC user's manual and data sheet and a Dial-A-Helper user's manual.

# C Compiler Introduced for HPC Family Development

***A new C compiler is now available for National's HPC family of CMOS 16-bit microcontrollers which can be used to develop HPC softeware on IBM PCs or compatibles running PC-DOS or MS-DOS.***

The compiler supports the standard Kernighan and Ritchie C language, featuring several enhancements designed to make HPC programming easier and reduce the amount of compiled C code that is generated. These include the support of two non-standard statement types, LOOP and SWITCHF.

The LOOP statement is not in standard C, but has been introduced to allow programmers to save code space in tight loops by using the HPC's "decrement and skip if zero" instruction to control looping.

SWITCHF is a special type of SWITCH instruction that reduces assembled code by not generating code to check the bounds of the value being jumped. The C compiler also allows users to define the memory configuration of the HPC processor and include assembly code within the C language program.

**Memory Definition**

Because microcontrollers–unlike microprocessors–use ROM memory to store programs and RAM to hold data, compilers must define the memory configuration of the processor. This feature has been added to the compiler.

The HPC C compiler can also accept assembly language instructions along with high-level language instructions. This allows programmers to write very compact sections of code, reducing the amount of memory required to store it. Switching between standard C and HPC C is also allowed. Users can compile HPC C programs under standard C and run them under the UNIX™ operating system, for example.

The HPC C compiler is available from stock on IBM-compatible 5¼ inch disks for $595.

An evaluation module is offered at no charge. Called the HPC C Compiler Evaluation Module, it is identical to the full version but is limited to about 1,000 lines of assembled cose (3K bytes). It can be obtained through National sales offices or DIAL-A-HELPER, the company's on-line applications support service.

# Core Concept Doubles Microcontroller Memory

***The COP840C, the latest ROM-based member of the COP800 family, builds on National's COP800 core architecture. The result: a powerful microcontroller with twice the ROM and RAM memory of the COP820C.***

Featuring 2K bytes of ROM and 128 bytes of RAM, the COP840C is perfectly suited for very complex microcontroller applications, including AC motor control, process control and heating-ventilation/air-conditioning (HV/AC) control.

According to Richard Sessions, product manager, the COP840C is designed for those complex uses. "The device will find its way into systems that require a very high level of performance from their microcontrollers," he notes.

## Common At The Core

A common CPU serves as the brain of all members of the COP800 family, just as a common core is at the heart of National's 16-bit HPC microcontroller family. By adding a different mix of memory, on-board peripherals and I/O functions, users can match devices in the family to a wide range of specific applications.

The core consists of an arithmetic logic unit (ALU), five 8-bit working registers, three multi-sourced interrupts, one 16-bit timer/counter with an auto-reload/capture register, control logic and "watch-dog" circuitry. In addition, it features MICROWIRE PLUS,™ a serial synchronous communications interface that allows easy connection of external peripherals or other controllers (see this issue's application note for more on MICROWIRE).

Fabricated in the modern Arlington, Texas fabrication facility with National's 2-micron M²CMOS process, the COP840C operates over a voltage range of 2.5 to 6 volts.

## Accurate Emulation

The microcontroller will operate in a "ROMless" mode to permit accurate emulation or the use of external program memory. A 15-bit program counter allows direct addressing for 32K bytes of memory. Other operating modes include single chip and test.

Addressing modes include register indirect, register indirect with auto-increment and decrement, direct, immediate and relative.

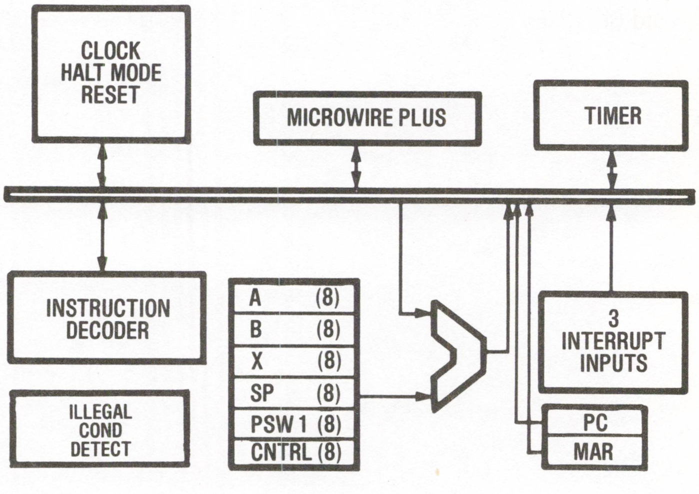
Single-byte, multi-function instructions make the COP device very code-efficient. In addition, because the COP840C features a 1 microsecond instruction-cycle time–and most instructions are single byte–the microcontroller executes all but a few of its instructions in only 1 microsecond.

## Illegal-Condition Detection

The COP840C also features illegal-condition detection. Attempts to address "illegal" ROM or RAM or "overpop" the instruction stack cause a software interrupt to be generated. The interrupt can be used to set a recovery routine in motion that re-establishes the microcontroller process.

Like all members of the COP800 family, the COP840C is supported by MOLE,™ an inexpensive, PC-based development system. MOLE (Microcontroller On-Line Emulator) backs the microcontrollers from initial software development to final hardware emulation and ROM pattern submission.

The COP840C, with 24 input/output pins, is form-, fit- and function-compatible with the COP8720C and the ROM-based COP820C/21C/22C. It is available in 28-pin DIP and PCC packages. The COP841C (24 pins) is offered in DIP and SO packages.



## New 16-Bit HPC Microcontroller Features Extra ROM On-Chip

***With 8K bytes of on-chip ROM, the HPC16083 is ideal for automotive applications such as anti-skid braking systems and automotive-engine-control.***

The HPC16083 microcontroller has a fourth input-capture register and features twice the ROM of other family members. It is suited for any general-purpose application requiring extra ROM; a ROMless version, the HPC16003, is also available.

The core processor, rated at a world-fastest microcontroller speed of 17 MHz over the full temperature range, is a 16-bit CPU with six working registers, a micro-instruction ROM, a clock generator, four 16-bit timer/counters, control logic, "watch-dog" circuitry and National's MICROWIRE/PLUS™ serial I/O bus interface.

The internal data paths and ALU are all 16 bits wide. Direct internal/external addressing through 64K bytes of memory allows interfacing to external memory, peripherals or other processors.

Three input-capture registers, 4K bytes of ROM and an on-chip UART were featured on the first HPC device, the HPC16040, introduced in March 1986.

### Low-Cost Development Tools

The HPC family is supported by a wide range of low-cost development tools offered by National. These include high-level language compilers and assemblers for a variety of host computers, including PCs, the MOLE™ development system and an HPC evaluation board (see related stories).

## A "PEARL" Of A Chip For HPC Applications

***The HPC16900 Port Expansion and Re-creation Logic (PEARL) chip has an Emulator mode for use with external memory, giving designers a device that frees up I/O pins that are so crucial to microcontroller applications.***

The CMOS PEARL support chip for National's HPC family of high-performance microcontrollers features two I/O modes, 36 multi-purpose I/O pins, and a wide voltage supply range of 3.0 to 5.5 volts. It also includes a Port-Expander mode to increase the number of system I/O ports.

When using external memory with an HPC, Port A and 4 bits of Port B on the HPC are used as multiplexed address/data and control lines. The HPC16900 can be used in emulator mode to regain the use of the ports by re-creating them. The PEARL chip entirely re-creates the HPC's Port A and 4 bits of Port B and provides all the logic needed to address external memory (PEARL Port E).

In Port-Expander mode, the HPC16900 provides 36 I/O pins that can be used as general purpose TRISTATE™ I/O.

### Parallel Performance

The PEARL chip supports EXPANDED, EXPANDED ROMless, and EXPANDED UPI (Universal Peripheral Interface) HPC modes.

As many as four of the chips can be used in parallel without additional logic, for a total of 160 general purpose I/O lines.

The HPC16900 PEARL chip is available in 68-pin PLCC (plastic leaded chip carrier), LCC (leadless chip carrier), and PGA (pin grid array) packages.

# New 8-Bit Microcontroller Has E²PROM in ROM and RAM

***A new addition to National's 8-bit COP microcontroller family is ideally suited for prototyping applications or small production runs.***

The COP8720C features 1K bytes of E²PROM in its ROM address space and 64 bytes of E²PROM in its RAM address space. The latter can be used to store information vital to the performance of process control, robotic and telecommunication equipment. The E² in ROM serves as program memory and may hold program instructions or constant data, such as look-up tables.

Because the COP8720C features a 1 microsecond instruction-cycle time, and most instructions are single byte, the controller executes all but a few of its instructions in just 1 microsecond. In addition, single-byte, multi-function instructions make the COP device very code-efficient.

For data memory, the 64 bytes of E²PROM in the RAM address space is supplemented with an additional 64 bytes of standard RAM. The data E²PROM can be accessed in the same way as the on-chip RAM.

**Fault-Free Operation**

In order to guarantee fault-free operation of the E²PROM modules, the microcontroller is provided with on-chip support circuits which generate all required high-voltage programming pulses. Fabricated with National's 2-micron M²CMOS process, the COP8720C operates over a voltage range of 2.7 to 6 volts. Operating modes include single chip and test. Addressing modes are registered indirect, register indirect with auto-increment and decrement, direct, immediate and relative.

The COP8720C is also equipped with MICROWIRE/PLUS,™ a serial synchronous communications interface that allows easy connection of external peripherals or other controllers. The interface consists of an 8-bit serial-shift register with serial-data input, serial-data output and a serial-shift clock. As an additional feature, the COP8720C microcontroller has an integrated on-chip 16-bit timer with an auto-reload/capture register.

Like all COP800 products, the 8720C features illegal-condition detection. Attempts to address "illegal" ROM or RAM or "over-pop" the instruction stack cause a software interrupt to be generated. This interrupt can be utilized to set a recovery routine in motion that re-establishes the microcontroller process.

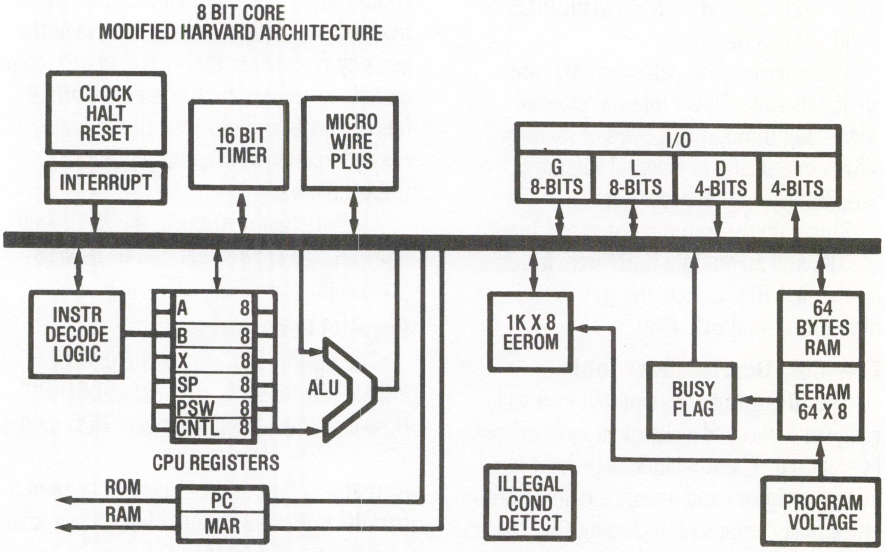
The COP8720C is form-, fit- and function-compatible with the COP820C/21C/22C ROM-based versions of the 8-bit microcontroller family.

**Common Core Flexibility**

The new device embraces National's microcontroller "core" concept, where a common CPU serves as the brain of all members of a particular family. By adding a different mix of memory, on-board peripherals and I/O functions, users can match devices in the family to a wide range of specific applications.

The 8-bit microcontrollers have an arithmetic logic unit (ALU), five 8-bit working registers, three multi-sourced interrupts, one 16-bit timer/counter with auto reload/capture, control logic, "watch-dog" circuitry and a MICROWIRE/PLUS™ interface for connecting peripheral devices.

The COP8720C has 24 input/output pins. Two ports are 8-bit software-configurable. The D and I ports are 4-bit output and input ports, respectively.



# HPC MathPack I: New HPC Software Support

***Two new software packages for the HPC family of 16-bit CMOS microcontrollers support test equipment, instrumentation and digital signal processing applications.***

One package implements a floating-point routine, and the other is a Fast-Fourier Transform (FFT) program. The floating-point package is written in HPC assembly code for compactness and speed, and can be used with the unit's C compiler. The compiler allows users to define the memory configuration of the HPC processor and include assembly code within the C language program (see related story in this issue).

The package features an ASCII-to-binary and binary-to-ASCII utility, which automatically converts characters and numbers entered from a keyboard into binary. ASCII characters are returned back from the program.

The program is a single-precision implementation based on the IEEE standard for binary floating-point arithmetic. In order to accommodate the HPC architecture, there are several differences between the version offered and the IEEE standard package. An application note available from National, numbered AN-486, lists the differences as well as the complete program.

## Fast-Fourier Transform

The FFT program is set up to do Fast-Fourier Transforms of 2, 4, 8, 16, 32, 64, 128, and 256 inputs or bytes and can be easily modified to work with larger lengths. Another application note, numbered AN-487, details the package and provides a program listing.

Both software packages, called HPC MathPak I, save system designers time that would have been spent coding the mathematical functions. They can now download the code from National's Dial-A-Helper service and include it in application programs. Dual-A-Helper is an applications support service provided by National's Microcontroller Applications Group.

## MathPaK for COP800C Family

For the COP800C family, COP800C MathPak I contains basic mathematical funtions that are written in CPO800C Assembler code. These include BCD and binary add and subtract; 8 by 8, 8 by 16 and 16 by 16 multiply; and 8 by 8, 16 by 8, 16 by 16, 24 by 16 and 32 by 16 divide. Also included are BCD-to-binary and binary to BDC conversions.

COP800C MathPak I is unique because code for all the routines is written in two ways: minimum code for higher ROM efficiency and optimized code for faster throughput. Programmers can chose either one to tailor system designs.

COP800C MathPak I is offered at no charge through Dial-A-Helper or from FAEs.

# New Evaluation Board For HPC 16-Bit Microcontrollers

***The MOLE-HPC-DB1 Board saves designers time and money by providing some of the emulation and debug capabilities offered on National's HPC MOLE™ system—at a lower cost.***

The Evaluation Board can be operated from a single 5-volt power supply. It lets users take control of the HPC processor through an RS232 serial port and execute code from memory space, which is either 4K or 8K-bytes of ROM. Users can also assemble a program on a line-by-line basis, list the program memory in either mnueumonic or hex form and examine and modify the internal registers and RAM of the HPC.

The board consists of the HPC microcontroller with an on-chip UART, RAM for internal ROM replacement and monitor use, A PEARL (Port Expansion and Recreation Logic) chip to reconstruct the I/O, two RS232 connectors, monitor ROM, two 34-pin connectors that allow users to wire the HPC into a system and miscellaneous logic.

**Easy Emulation**

The board is connected to a target system through an emulation cable that is plugged directly into the user's application system. The HPC evaluation board "mimics" the HPC, letting the user's application circuit respond to the emulator the same way it would to the HPC. It attaches itself to the application circuit instead of the HPC chip, producing the same signals—with the same timing—as the final HPC chip.

Application development with the board is accomplished in four steps: a prototype application circuit is made, a C or Assembly program is written on the host system, the evaluation board's monitor executes the user program and the program is debugged.

Evaluation board firmware and hardware make debugging possible. A single-stepping feature, which uses breakpoints automatically set up by the monitor firmware, allows program execution to be stopped after each instruction. Because the program is being executed by an HPC chip, the evaluation board always knows which address is being accessed.

The HPC evaluation board supports emulation of systems which have expansion RAM external to the HPC chip. Users do not have to remove external memory while using board-emulation RAM, as long as the evaluation board jumpers are set properly.

The HPC evaluation board features 8K bytes of on-chip emulation RAM. Additional memory can be added on the target system, with the HPC running in either the EXPANDED or EXPANDED ROMless modes.

The 5-volt power supply and RS232 cables are supplied by users.

# Microprocessors

For additional Microprocessor products, see pages 141 and 321.

## CMOS Series 32000® Keeps Its Cool

***National's Series 32000 CMOS 32-bit microprocessors dissipate less heat than competitive devices, giving them the edge in applications requiring low power consumption.***

The inherent low-power characteristic of CMOS technology makes it the process of choice in applications where heat dissipation is critical. CMOS devices offer improved immunity to noise in harsh environments and help to smooth performance in extreme temperatures, giving them the edge in portable, battery-operated, military and industrial control applications.

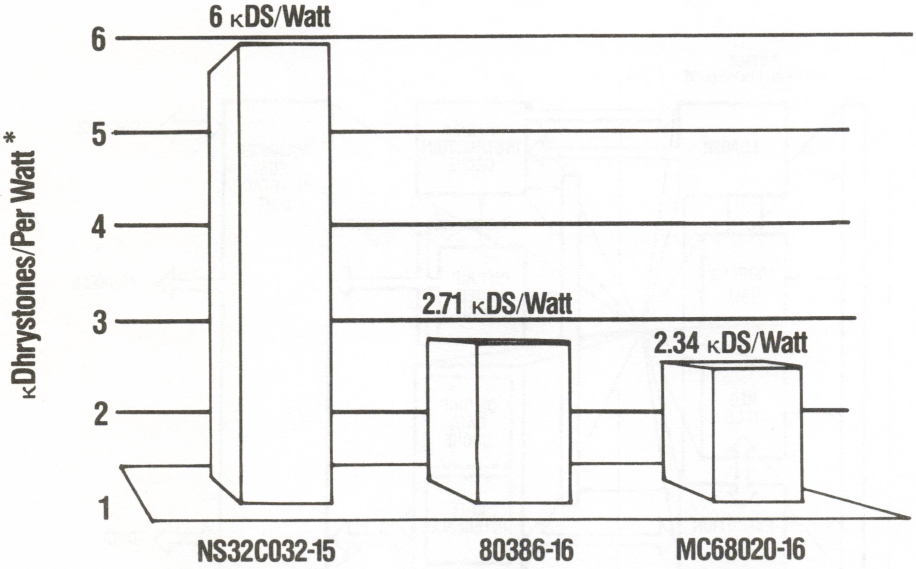
### Less is More

National's CMOS Series 32000 32-bit microprocessors offer the lowest power consumption in the industry. For example, National's NS32C032, the industry's first full-CMOS 32-bit microprocessor, dissipates only 350 milliwatts. Competitive 32-bit devices, meanwhile, dissipate up to and beyond 2.0 watts.

This higher power consumption places these competitive microprocessors at a disadvantage in many CMOS applications where heat dissipation is the primary consideration. The NS32C032 offers an attractive performance/power ratio; benchmark studies show it performing at 6 kDhrystones for every watt consumed, a substantially better ratio than that offered by the other 32-bit CMOS microprocessors in the industry.

In addition, the NS32C032 is priced considerably less than its competitive counterparts.

The NS32C032 and NS32C016 are software-compatible with all other Series 32000 microprocessors.



***Calculated from Specifications Published in Industry Databooks**

## New Development Board Accelerates Series 32000® Designs

***The DB332-PLUS is a high-performance, 15MHz, NS32332-based board that enables designers to evaluate National's NS32332 computer cluster and Series 32000 family.***

The Series 32000 instruction set, cycle timing, bus interfacing and internal architecture can be examined by using the DB332-PLUS. The board also provides a native debug and execution environment for programs developed on a host computer.

### Computer Cluster On-Board

The on-board computer cluster consists of the NS32332 Central Processing Unit (CPU), NS32382 Memory Management Unit (MMU), NS32081 Floating Point Unit (FPU), NS32C201 Timing Control Unit (TCU) and NS32202 Interrupt Control Unit (ICU).

The 15MHz NS32332 is a 32-bit, virtual-memory microprocessor with a 4 GByte addressing capability. It is fully object-code compatible with other Series 32000 microprocessors and works in conjunction with the 32-bit slave processors in the Series 32000 family.

The MMU provides hardware support for demand-paged virtual memory management, while the FPU provides high-speed floating-point processing support and compatibility with the IEEE 754 standard for binary floating-point arithmetic.

### Boarding The MULTIBUS® Architecture

The DB332-PLUS incorporates a MULTIBUS I interface, allowing users to configure larger systems. It may also be employed in a stand-alone mode when used with an RS232-compatible terminal and a power supply.

The board can be connected to another computer system or host. Here, Series 32000 software is developed on the host system and then downloaded via the RS232 communications link to the DB332-PLUS, which executes and debugs the software in a native environment.

# The NS32532: Powerful 32-Bit Processing On The Horizon

## *National previews the forthcoming highest-integrated, highest-performance 32-bit microprocessor in the industry.*

Specifications for the latest-generation Series 32000® microprocessor, the NS32532, have been announced to the public. Among the device's most prominent features: an on-chip, demand-paged, virtual memory management unit (MMU); on-chip instruction and data caches; and an 8-10 MIPs (VAX 780) average performance (with-up to 15 MIPS peak performance). The NS32532 also features broad real-time and multiprocessing versatility, and full software compatibility with previous Series 32000 processors and peripherals, including the NS32332 CPU and NS32383 MMU. Sampling of the NS32532 is due to begin in late 1987, with volume production scheduled immediately thereafter.

The new microprocessor has a full 32-bit architecture optimized for high-performance applications. With over 370,000 transistors, it features an extremely high level of integration. Its MMU offers a 64-entry, fully associative Translation Lookaside Buffer (TLB). Its instruction cache is a 512-byte, direct-mapped implementation, while its data cache is a 1,024-byte two-way set associative cache. In addition, the chip features a four-stage overlapping instruction execution pipeline.

The NS32532's current performance specs define a peak performance of 15 MIPS, with an average of 8-10 MIPS at a clock frequency of 30 MHz. It has an internal memory bandwidth of 240 Mbytes/second and an external bus bandwidth of 92 Mbytes/second. First release versions will have a 20 MHz clock rate, with higher-speed releases coming soon after as the design is scaled from a 1.5-micron double-metal process to a 1-micron line width. The CPU also addresses 4 gigabytes (billion bytes) of virtual and physical address space, and it is offered in a 175-pin-grid-array package.

The NS32532 is expected to open the door to a number of high-end applications which demand extremely fast execution times or have a critical need for hardware/software compatibility. In many cases, National's new CPU will make 32-bit technology accessible to applications that to date have not been a part of the 32-bit market–which is now focused mainly on personal computers and workstations.

Military applications, for example, can take advantage of the NS32532 in a variety of environments: fault-tolerant systems, high-performance parallel- and vector-processing systems, avionics and instrumentation, flight control systems, weapons delivery, simulators and other embedded control systems, and research and development projects.

High-end control applications can enjoy the same level of performance found in traditional bit-slice architectures, yet with the ease of standard software development and without the penalties associated with complex, non-standard developments.

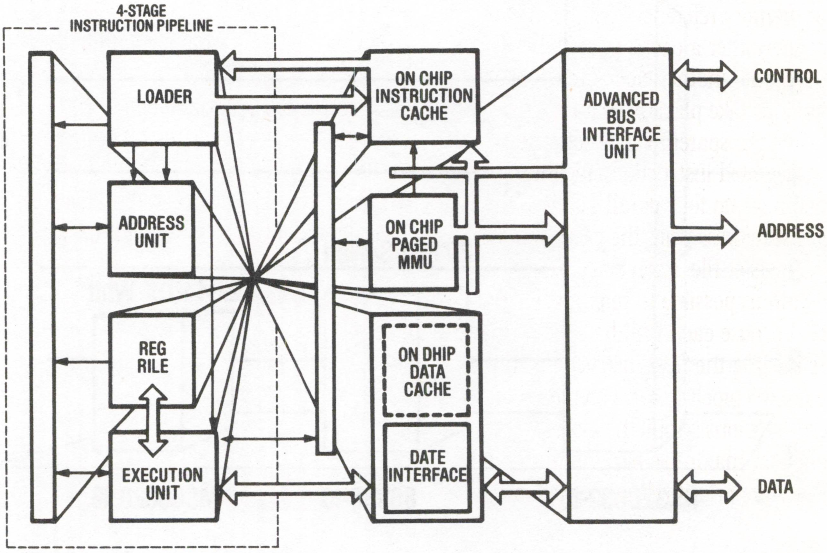
### Real-Time, Multiprocessing Versatility

One of the major marketing issues National has focused on is the versatility of the NS32532–most significantly, its ability to function equally well in both real-time and multiprocessing environments.

For example, the NS32532 has an interrupt response (1.3 microseconds) and context switch time (3.6 microseconds) that is up to four times faster than any microprocessor currently available, making it appealing for real-time controller applications.

For multiprocessing, the 532 is also the sole 32-bit microprocessor on the market that can support an efficient bus-watcher mechanism to maintain internal cache coherency with multiple caches. For real-time applications, the NS32532 also has cache locking to keep key routines or data immediately available to the CPU.

The caches are accessed in parallel with address translation to optimize performance. The 64-entry Translation Lookaside Buffer (TLB) virtually guarantees (with greater



than 99 percent probability) that memory requests will already be located within the translation buffer (a "hit").

The integrated instruction and data caches, MMU, and TLB offer increased execution speed because of reduced external memory references. Cache size was critically engineered for efficiency to offer maximum probability of a cache hit.

### Unique Hardware And Software Cache Invalidation

To maintain coherency between the CPU's caches and main memory, the NS32532 employs hardware cache invalidation mechanisms. These mechanisms invalidate cache entries, or the entire cache, to maintain coherency with corresponding memory locations. This avoids the performance compromises which result when the same cache monitoring and invalidation is done in software.

No other microprocessor offers both hardware and software cache invalidation. The NS32532 hardware cache invalidation does not degrade performance.

An external read to memory is initiated concurrently with the internal cache lookup so that memory references can be made immediately after a cache miss without having to wait another clock cycle. Cache invalidations take place in real-time, completely transparent to the software.

An integrated instruction pipeline is structured into four parallel stages: the loader, the address unit, the execution unit and the register file. Each stage buffer is kept as full as possible to maximize performance. Because each unit has one or more buffers holding the next instructions in the sequence, the pipeline can execute up to seven instructions simultaneously.

To further maximize performance, read operations are prioritized over write operations. But to maximize efficiency, National integrated an I/O detection mechanism which ensures that read and write operations with I/O devices are performed in the correct order and only when required.

Having such a high level of integration allows the NS32532 to take advantage of half-clock cycles for fast interleaved accesses. Virtual-to-physical address translations can be performed in parallel with other operations (such as the cache look-ups).

### Compatible Design Philosophy

The hallmark of the entire Series 32000 family has been a common, 32-bit architectural base, making every CPU and peripheral upward and downward software-compatible.

The NS32532 is the ultimate expression of that design principle. It has been created to support high-level language, because HLL programmers can be more productive than assembly-language programmers—largely through the efficiencies of optimized compilers. National designed the Series 32000 architecture specifically to support HLL compilers.

In conjunction with its software and development tools, the NS32532 allows designers to migrate both vertically (through performance levels) and horizontally across a range of applications.

Because of this compatibility—and because it can be configured with hardware and software to meet a variety of specific design objectives—the NS32532 can deliver high-end computing power with far less up-front design time.

# New GENIX Language Tools For Series 32000

***National introduces the second release of the Series 32000® Native and Cross-Support (GNX™) Language Tools. Optional compilers generate high-quality code 30 to 200 percent faster than previous compilers.***

The software development tools are based on AT&T's Common Object File Format (COFF).

According to Kim Ingram of National, code generated by the tools can be executed in any GENIX/V environment when used with appropriate command-line arguments and when linked with appropriate libraries.

In addition, the tools can be used to create operating system-independent code or code designed to run in conjunction with real-time kernels, such as National's EXEC and VRTX® Series 32000.

### Optional Compilers

Optional compilers are available, including an optimizing C compiler, optimizing FORTRAN 77 compiler and Pascal compiler to ensure uniform portability to UNIX,™ VMS™ and native operating environments and to make the Series 32000 CPUs perform as fast as possible.

The optimizing C compiler is a complete implementation of the original C language definition. The FORTRAN compiler is a full ANSI-X3.9-1978 standard implementation with UNIX 177 extensions. And the Pascal product is a full ANSI/X3J9-1981, ISO level 1 implementation, including enhancements such as modular compilation capabilities.

### Optimized for GENIX/V.3

The GNX tools are offered as an option for National's new GENIX/V.3, a port of AT&T's Unix System V, Release 3.0 operating system.

GENIX/V.3 is a multitasking, multiuser operating system that provides a large number of programs and utilities for text processing, program development and system administration.

Release Three carries forward all the enhancements from system V/Series 32000, such as demand-page virtual memory and file and record locking, while introducing significant new features that support local area networking.

Those features include streams–a general, flexible facility for the development of communications services within the UNIX operating system. Streams provide a consistent framework for the operation of network services.

Other new features are Remote File Sharing (RFS), a facility which allows a group of computers to be linked, and two libraries: Transport Level Interface (TLI) and Transport Provides Interface (TPI). These libraries help the protocol-developer produce protocols that conform to industry standards.

# VME532: Highest VMEbus CPU Performance In The Industry

***National's new VME532 board-level computer provides users with two to three times the performance of existing VME solutions while maintaining compatibility with UNIX® and VRTX® software.***

The new board-level computer features National's NS32532 32-bit microprocessor and the high-end Series 32000® chip cluster. It executes up to 10 million instructions per second (MIPS), making it the highest performance VMEbus CPU currently available. The board functions as an off-the-shelf platform that offers performance comparable to that of high-end super-minicomputers such as the DEC VAX™ 8700, the Data General MV/20000 or the Prime 9955.

Solutions based on National's VME532 offer significant cost advantages when compared to minicomputer alternatives. Systems integrators need merely supply system packaging and I/O in conjunction with the board, which is priced under $10,000. This total outlay of between $25-50K contrasts sharply with the $500,000 investment that a typical high-end super-minicomputer entails.

### Board-Level Design Alternative

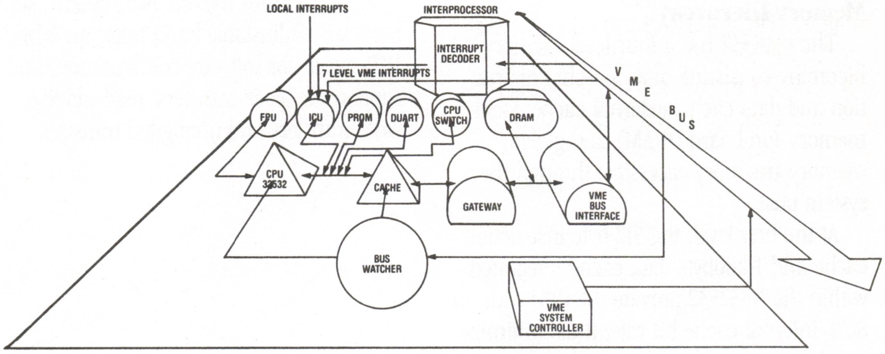
With the introduction of the VME532, National offers new alternatives to engineers developing Series 32000-based applications. Designers can now choose the appropriate level of CPU integration–chip or board–while retaining compatibility, through the industry-standard VMEbus, with a broad range of memory, mass storage and specialized I/O interfaces available from hundreds of third-party vendors.

The VME532 is designed and packaged specifically for organizations whose hardware and software engineering teams are integrating boards from multiple vendors into a volume end product. Choosing the VME532 can help such a product to reach the market more quickly, and with less design risk, than a solution engineered from the chip level.

### The Multiuser Microprocessor

The VME532 is an ideal solution for systems integrators building high-performance UNIX System V-based multiuser systems that accommodate between 32 and 200 users. National's GENIX™ software, used in conjuntion with the VME532, supports Ethernet and TCP/IP networking in multiuser applications. GENIX also supports a suite of languages: PASCAL, FORTRAN77, C, Modula 2 and Ada.

The VME532 design easily accommodates multiprocessing applications. It supports both loosely and tightly coupled systems, and enables up to 16 processors to be installed within the overall system. This



optimizes it for other high-performance, board-level embeddedcontrol applications such as automated test equipment, factory automation, imaging applications and aircraft flight simulators.

The VME532 also opens the door to new applications in research labs. For one, it can be used to evaluate the architecture, timing and performance of the NS32532. It also provides a native debug and execution environment for programs developed on a host computer, and it is compatible with National's GNX™ software development tools package, including the family of optimizing compilers (see related story in this issue for more on the compilers).

Finally, the board's high performance and ability to execute Ada language programs in a native environment makes it an excellent choice for demanding military and aerospace embedded applications.

### NS32532 On-Board

The VME532 consists of a two-level board incorporating National's 20-MHz NS32532 and members of the Series 32000 chip cluster, including a floating point unit and an interrupt control unit.

Featuring on-chip memory management, the NS32532 is the highest performance member of the Series 32000 family of 32-bit microprocessors. Plans call for a 30-MHz version of both this device and the VME532 to be introduced later this year.

### Memory Hierarchy

The VME532 has a four-level memory hierarchy consisting of an on-chip instruction and data cache, external cache, local memory (on-board DRAM) and global memory (memory accessible through the system bus).

At the first level, the 512-byte instruction cache and 1-kilobyte data cache integrated within the NS32532 provide the CPU with an 80% internal cache hit rate, thus minimizing the number of external cache accesses.

At the second level of the memory hierarchy, wait-states are eliminated on over 90% of memory accesses–thanks to a 64-KByte external, direct-mapped, write-through cache. With up to 16 MB of DRAM on board, the VME532 provides a cacheable memory address range of up to 256 MBytes.

Level three consists of 4 MB of DRAM (expandable to 16 MB) configured as a local dual-port, parity-checking memory. This allows access through the system bus, as well as through an independent local bus. Finally, the fourth level in the memory hierarchy allows each processor's local memory to serve as global memory to other CPUs in a multiprocessing system.

### Multiprocessing Features

By monitoring VMEbus write traffic and performing necessary local invalidations, the VME532 provides hardware cache coherency. Its local memory permits large numbers of high-performance CPUs in an application without saturating the VMEbus. In addition, the board supports up to 16 CPUs per VMEbus via a thumbwheel switch that sets memory mapping and register addresses.

Interrupts are controlled by an on-board NS32202 interrupt-control unit. This 16-channel device handles all on-board interrupts, all seven levels of VME interrupts and the inter-processor interrupts that are generated in multiprocessing systems.

Other features include two RS-232C serial ports with adjustable baud rates; an 8-bit DIP switch for software configuration; and support for block transfers, read-modify-write transfers and unaligned transfers.

# New Series 32000® Development Package For PC/AT™ Environment

***National's new SYS32/30 Development Package converts PC/ATs and compatibles into powerful UNIX® multiuser systems for the development of applications based on the Series 32000 microprocessor family.***

The SYS32/30 package consists of an add-in coprocessor board containing the Series 32000 chip cluster, software and complete documentation. As an enhancement of National's popular SYS32/20 package, it is designed to support up to eight users by virtue of its added memory configurations and increased processing power. The resulting package allows programs to run on a PC/AT or compatible at speeds far greater than those provided by a VAX® 780 minicomputer.

## Improved Programming Productivity

SYS32/30 provides users with increased throughput and increased responsiveness for development of their Series 32000-based programs. It accomplishes this task for *all* seven CPUs in the Series 32000 family, from the NS32008 on up to the new NS32532.

SYS32/30 employs National's 15-MHz NS32332 microprocessor, the NS32382 Memory Management Unit (MMU) and the NS32081 Floating Point Unit (FPU). While its precursor, SYS32/20, will continue to appeal to a wide range of users because of its attractive price/performance ratio, SYS32/30 takes the next logical step up the performance pathway provided by the Series 32000 family.

## Concurrent UNIX And DOS

SYS32/30 includes a complete port of AT&T's UNIX System V.3. A dual-processor architecture enables the SYS32/30's CPU to function as the main processor for the system while the PC's CPU functions as an I/O resource. Specially developed software provides for concurrent operation of the UNIX and DOS operating systems, allowing users to switch between the two with a few simple keystrokes.

The software integrates National's GNX™ language tools, which include an assembler, linker, debuggers, math libraries, and a monitor. PASCAL, C and FORTRAN 77 compilers are supplied as optional software to allow the language to be individually selected for the application. In addition, an Ada compiler is available which allows users to transform their PCs into Ada software development workstations.

## Memory For Multiuser Support

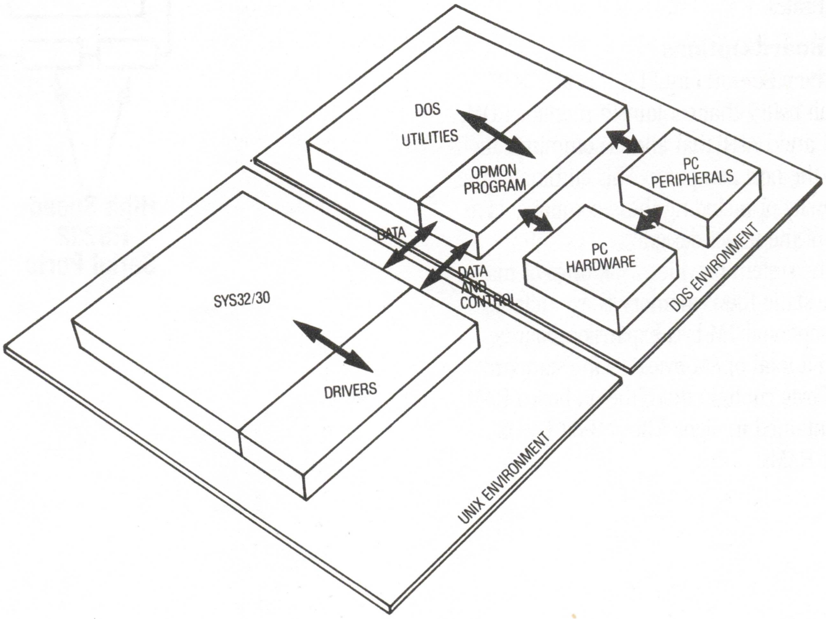
Several memory configuration options are included among the system's enhancements. SYS32/30 features on-board memory with zero wait-states, available on memory cards in either a 4-, 8-, or 16-MByte size.

These expanded memory options allow for more commonly used programs to remain resident in memory, thus bypassing any I/O constraints encountered by the PC/AT bus. More pages of user code and data can also reside in memory, reducing the paging load imposed on the I/O structure.

Another benefit provided by the SYS32/30 Development Package is the optional software support for the Ethernet networking protocols, enabling many PCs to be tied together to accommodate a wide network of multiple users.

## Easy Installation

The SYS32/30 board plugs into the PC/AT bus and uses standard control and data signals, thus allowing the PC to process I/O commands while SYS32/30 continues with regular operation. Two slots in the PC are required to accommodate the piggybacked memory board that is attached to the co-processor board.



# “SPLICE” Debugging Tool Joins Series 32000® Family

***A new low-cost board solution allows users to interface Series 32000 target systems to a host computer for debugging, downloading code and examining target resources.***

The SPLICE board is a versatile software debugging development tool that supports all Series 32000 32-bit microprocessors at their maximum rated frequencies, thanks to its ability to connect directly to the target CPU without buffering.

SPLICE is particularly cost-effective for debugging fast Series 32000 CPUs with clock speeds greater than 20MHz. It functions independently of specific CPU clock speeds, giving it the flexibility to debug different Series 32000 applications by adding only the appropriate CPU target cables. Independence from clock speeds also ensures that SPLICE will support all current and future higher-speed versions of specific CPUs in the Series 32000 family.

SPLICE connects to a variety of development system hosts, such as a DEC VAX® minicomputer or National's SYS32/20® PC-based development system. Connections to the host are implemented by means of RS232 serial ports with programmable baud rates.

**On-Board Options**

The base unit for SPLICE is a 7″×9″ circuit board that contains a monitor ROM, RAM and UART that allows communications with the host computer. This eliminates the necessity of including these components as part of the target design.

The system provides 256K-bytes of mappable static RAM; memory is expandable with optional 1M-byte expansion boards, up to a total of 8M-bytes. In the standard 256K-byte configuration, the on-board RAM is contained in eight 32K × 8-bit CMOS static RAMs.

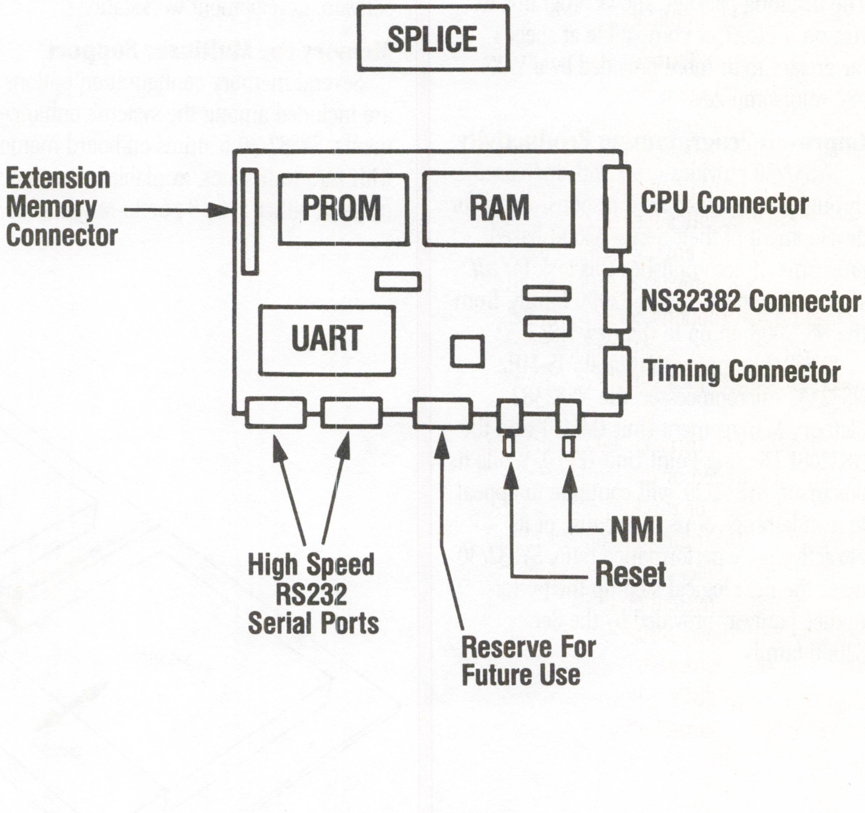
A total of 2K of the RAM is required for the monitor firmware, leaving the remaining RAM available to receive downloaded code. This allows software debugging in a target that is not fully completed, replacing non-existent target memory with SPLICE RAM memory.

**Interface Made Easy**

SPLICE connects to the target environment primarily through the CPU socket: the CPU is removed from the target socket and inserted in the SPLICE socket, while the SPLICE cable in turn is inserted into the target CPU socket.

SPLICE can be interfaced to the host computer in two ways. First, it can be connected in a flow-through mode, where it is positioned between a terminal and the host computer. The second technique calls for SPLICE to be connected only to the host, with all commands passed along the single serial line. This method is handy when the host system does not have a separate terminal connection.

SPLICE now supports all CPU members of the Series 32000 family, as well as the NS32382 Memory Management Unit (MMU). Plans call for a separate SPLICE unit that will support National's upcoming NS32532 microprocessor, the newest member of the Series 32000 family.



# New Real-Time Software For Embedded Series 32000® Applications

***National's VRTX® real-time operating system for Series 32000-based embedded applications is now complete with the addition of an input/output executive and a multitasking, real-time file manager.***

The two new Series 32000 R&D packages are known as the IOX®/Series 32000 (Input/Output Executive) and the FMX®/Series 32000 (File Management Executive). When used in conjunction with the VRTX/Series 32000 executive and the TRACER™/Series 32000 interactive multi-tasking debugger, these software-in-silicon building blocks provide users with a complete, real-time operating system solution for Series 32000-based embedded applications.

## IOX: The Input/Output Executive

The IOX package is a companion software component for the VRTX/Series 32000 which provides embedded microprocessor applications with a powerful set of input/output (I/O) facilities for use in a multi-tasking, real-time environment. Like VRTX, IOX is a silicon software component that makes no assumptions concerning its target environment and therefore can be used unchanged in a variety of custom applications.

IOX tasks can transfer data to or from devices in buffered or direct mode, using either sequential or random access. In buffered mode, IOX maintains one or more intermediate buffers that isolate applications tasks from the physical characteristics of devices. This allows serial devices such as terminals to coexist with random access devices such as disks, with mutual access provided by the same buffered IOX calls.

IOX's direct mode provides a set of services that can transfer data or perform device-specific control operations and synchronization in applications that require close control over device operations. The programmer is freed from hardware-dependent considerations such as device addresses, commmand codes and interrupt handling.

## FMX: The File Management Executive

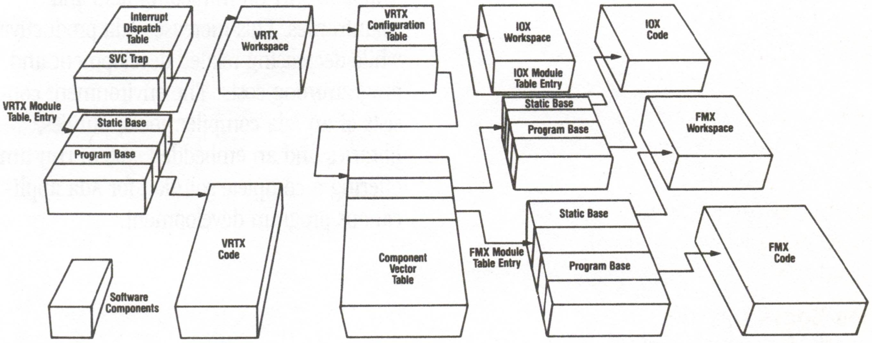
The FMX package is designed to provide disk file management services for VRTX- and IOX-based software systems. It permits the organization of related information into resources called files and allocates these resources to tasks. Like the VRTX and IOX packages, FMX/Series 32000 is software-in-silicon and thus makes no assumptions about the target environment.

FMX operations permit tasks to create and delete files, to assign attributes to those files, and to open IOX channels to them for subsequent use by IOX read and write operations. Along with other multi-tasking requirements, FMX supports con-current file accesses and both buffered and unbuffered direct read and write operations. Both sequential and random access methods are provided.

FMX has a facility for formatting disks which may be used to produce PC DOS-compatible formats. It supports a hierarchical file structure compatible with Version 2.0 of PC DOS.

## Hot-Line Technical Support

National offers a one-year complete technical support period for all software components of the VRTX solution, including the IOX and FMX packages. Originally developed by Hunter and Ready Corporation (now known as Ready Systems, Inc.), all of the VRTX real-time software components were ported to the Series 32000 by National, which sells, services and supports the packages.



# DOD Validates National's Ada Development Environment

***National offers the first commercially available 32-bit Ada Cross-Development Environment on a personal computer, targeted for Series 32000®-based embedded systems applications.***

National's version of the Ada Development Environment is the first Ada cross-compiler for Series 32000 applications to be validated by the Department of Defense. Used in conjunction with a Series 32000-based IBM PC coprocessor add-in board and the System V/Series 32000 operating system (collectively known as National's SYS 32/20 development system), National's solution allows users to develop embedded Series 32000 Ada applications on a PC for the first time.

National worked closely with Verdix Corporation of Chantilly, Virginia to develop the environment. Verdix, a computer system and software development company specializing in Ada, spent 18 months in research and development on the project. Verdix previously has developed native Ada products for several of National's Series 32000 customers.

## Power To The PC

National's ADA Environment offers PC users a complete Ada applications program development capability that previously was available only on minicomputers and mainframes. This increases Ada productivity while decreasing related development and programming costs. The environment consists of an Ada compiler, tools, utilities, libraries and an embedded system run-time, offering a complete solution for Ada applications program development.

"The key to National's solution is that it opens the door to customers developing embedded Series 32000 Ada applications," says Bill Slusher, National's Ada Program Manager. "As the first host-to-target Series 32000 Ada cross-compiler, it addresses mission-critical, defense-oriented embedded systems and other real-world concerns. PC-hosted applications have their place, but its hardly practical to put a complete development system in an intelligent weapons system, for example."

## Available For Minicomputer Hosts

National has also released a version of its ADA Development Environment for DEC VAX™ and MicroVAX/VMS™ systems which will also produce code for embedded "bare" Series 32000 microprocessor targets. By offering Ada products that support both micro and minicomputer host program development, National now provides an Ada solution for the majority of Ada engineering development environments, independent of host computer type.

Ada is the Department of Defense's mandated computer program language for mission-critical and defense-oriented embedded systems applications.

**FOR INDEX OF NATIONAL SEMICONDUCTOR PRODUCTS, SEE PG. 223**

**FOR INDEX OF FAIRCHILD SEMICONDUCTOR PRODUCTS, SEE PG. 393**

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Av. Brig. Faria Lima, 830
8 Andar
01452 Sao Paulo, SP, Brasil
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Telex: 391-1131931 NSBR BR

**National Semiconductor GmbH**
Industriestrasse 10
D-8080 Furstenfeldbruck
West Germany
Tel: (0 81 41) 103-0
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Neufahrn
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**National Semiconductor GmbH**
Misburgerstrasse 81D
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Zeppelinheim
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**National Semiconductor GmbH**
Kranstrasse 7/I.O.G.
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**National Semiconductor Ltd.**
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**National Semiconductor**
France S.A.
Expansion 1000
28, rue de la Redoute
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France
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**National Semiconductor S.p.A.**
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**National Semiconductor AB**
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**National Semiconductor (Netherlands)**
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**National Semiconductor**
Kauppakartanonkatu
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Tel: (90) 33-80-33
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**NS Japan Ltd.**
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**National Semiconductor (Australia) PTY, Ltd.**
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**National Semiconductor Asia Pacific Pte. Ltd.**
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#13-01 Southpoint
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Taiwan Branch
7th Floor, Nan Shan Life Bldg.
302 Min Chuan East Road
Taipei, Taiwan R.O.C.
Tel: (02) 501-7227
Telex: 22837 NSTW

**National Semiconductor (Far East) Ltd.**
Korea Office
Room 612, Korea Fed. of
Small Bus. Bldg.
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